Multimodal e-feedback: An Empirical Study

Abdulrhman Abdulghani Alharbi

Thesis submitted for the degree of Doctor of Philosophy in Computer Science

Supervised by Professor Dimitrios I. Rigas

Faculty of Technology, De Montfort University

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The effect of multimodal metaphors on e-feedback interfaces in terms of usability and user engagement

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2013

بسم الله الرحمن الرحيم

In the Name of Allah, the Most Compassionate, the Most Merciful

DEDICATION

This thesis is dedicated to the most precious persons in my life - my parents, my wife and soul-mate, and my dear, beautiful sons Amr and Mohammad.

Abdulrhman Alharbi

ABSTRACT

This thesis investigated the applicability of unique combinations of multimodal metaphors to deliver different types of feedback. The thesis evaluates the effect of these combinations on the usability of electronic feedback interfaces and on the users' engagement to learning. The empirical research described in this thesis consists of three experimental phases. In the first phase, an initial experiment was carried out with 40 users to explore and compare the usability and users' engagement of facially animated expressive avatars with text and natural recorded speech, and text with graphics metaphors. The second experimental phase involved an experiment conducted with 36 users to investigate user perception of feedback communicated using avatar with facial expressions and body gestures, and voice expressions of synthesised speech. This experiment also aimed at evaluating the role that an avatar could play as virtual tutor in e-feedback interfaces by comparing the usability and engagement of users using three different modes of interaction: video with tutor that presented information with facial expressions, synthesised spoken messages supported with text, and avatars with facial expressions and body gestures. The third experimental phase, introduced and investigated a novel approach to communicate e-feedback that was based on the results of the previous experiments. This approach involved speaking avatars to deliver feedback with the aid of earcons, auditory icons, facial expressions and body gestures. The results demonstrated the usefulness and applicability of the tested metaphors to enhance e-feedback usability and to enable users to attain a better engagement with the feedback. A set of empirically derived guidelines for the design and use of these metaphors to communicate e-feedback are also introduced and discussed.

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List of Acronyms

3D	3 Dimensional
ABGP	Avatar Body Gestures Platform
ANOVA	Analysis Of Variance
ATM	Automated Teller Machine
CV	Critical Value
Df	Degree of Freedom
E-Feedback	Electronic Feedback
E-Learning	Electronic Learning
FTFP	Face to Face Platform
MMFI	Multimodal Metaphors Feedback Interface
SSP	Synthesised Speech Platform
SUS	System Usability Scale
VB	Visual Basic
VFI	Visual Feedback interface

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Chapter 1

Introduction

1.1 Preface

This Thesis investigates the use of multimodal metaphors to communicate information about feedback in e-learning interfaces. The aim of this investigation is to explore the suitability and appropriate design of metaphors based on different sensory channels in order to increase the level of usability in electronic feedback interfaces and to improve student's engagement with different types of feedback and content.

There is generally a significant importance attached to good quality feedback in learning [3, 5, 7]. It is therefore essential to deliver feedback in an effective manner to engage students with their learning objectives. There is however limited research on using multimodal metaphors to increase usability of e-feedback in terms of the way that is communicated regardless of its semantic content.

The development of interfaces for educational technology and technology enhanced learning in increasing rapidly. This is because of the important of delivering information to students effectively and the significance of feedback to students. Therefore, feedback is considered to be one of the most important issues in the learning process. Students wish to receive feedback by tutors in a clear and easily understandable manner. There is a general lack of e-feedback interfaces that deliver effective feedback. Studies showed that student do not engage with delivered feedback content [103]. E-learning interfaces are generally effective at presenting information but often lack or inefficient feedback results to the disengagement of students with the learning process.

Feedback in e-learning interfaces is primarily based on the visual channel using either text or graphics with symbols to annotate certain ideas. These visual interfaces designs lead to visual overload and do not take advantage of other channels of communication (e.g. auditory). The effect of a single channel communication approach is for the recipients of the information to take more time to interpret the information communicated.

Users of the e-learning and feedback systems are categorised in three groups, students, teachers and administrators. The users are interacting with the systems in two ways either input or output. Each user has the special privilege to deal with the system. These privileges are different from one user to other and based on the user's attribute. In this research the user that considered and needed to investigate is a student. The user in this research is dealing with e-feedback as output so the user will receive the feedback as output.

Another approach to the development of e-feedback interfaces is to use audio and to deliver feedback. The feedback content of a student is recorded by a tutor to be sent over to students. It is useful for some students who prefer to listen to feedback while they do some other visual activity. However, this approach also has limitations such as missing the face-to-face contact with the tutor and their facial expressions. A multimodal approach can potentially enhance increase the usability of an interface.

This thesis investigates unique designs of multimodal metaphors to increase usability on e-feedback interfaces and the effect of using multimodal metaphors on students' engagement with different types of feedback. The research presented in this thesis consists of three experimental phases. The first experimental phase compares between a traditional feedback interface and a multimodal metaphors feedback interface. The result of three experiments led us to set out guidelines for designing electronic feedback interfaces in terms of usability and student engagement with the content of the feedback.

The thesis present the audio-visual feedback types content through the e-feedback interfaces. The experimentation that is carried out in this research evaluates how speech and non-speech sound, avatars, and body gestures affect the usability and students' engagement of an e-feedback system and to examine and analyse whether approach of this thesis can bring a boost in effective communication of feedback.

1.2 Aims

The aim of this research is to investigate the role of multimodal metaphors in electronic feedback interfaces. Moreover, it investigates the role of text, recorded speech, synthesis speech, earcons, auditory icons, avatar facial expressive and body gestures in electronic feedback interfaces. Also, the research examines the sole use of these metaphors or combined to deliver effective feedback. The thesis aims to present the audio-visual feedback types content through the e-feedback interfaces by making use of the multimodal metaphors. The experimentation that is carried out in this research evaluates how speech and non-speech sound, avatars, and body gestures affect the usability and students' engagement of an e-feedback system and to examine and analyse whether approach of this thesis can bring a boost in effective communication of feedback. Usability is measured by the time spent by users to receive the feedback task based on the type of metaphors used and the successful completion of tasks by using different types of metaphors. Finally, students' satisfaction rates are considered as one of usability tests. In addition, students' achievement level and students' engagement with feedback content is measured to distinguish performance levels between interfaces.

1.3 Objectives

The objectives of the thesis involve the development of electronic feedback interfaces that facilitate the use of specific unique designs of multimodal metaphors. These interfaces created from the scratch and developed throughout the experiments phases. Also, specify the ways to measure the usability for each modal and interfaces. The platforms are used as a basis for a set of empirical experiments with different modalities including textual representations. The textual representation serves as a control which is a traditional feedback interface. For example, in the first experiment (see Chapter 3) a typical traditional feedback content presented by an electronic feedback interface.

1.4 Hypotheses

The overall hypothesis for the conducted research can be stated that using the multimodal metaphors makes the e-feedback interfaces more efficient, effective, engaging, and satisfactory with improved performance in contrast to the use of texture or graphical metaphors only.

1.5 Methodology

Several processes, strategies, and methods were used to accomplish the research of this thesis. The overall approach taken involved a literature survey that was followed by three experimental phases. The results obtained from the experiments evaluated parameters such as performance and efficiency and results from user questionnaires evaluated user satisfaction levels. The questionnaires were distributed to users of different ages and varied background. All obtained data both objective (measured) and subjective (user provided) were analysed and evaluated. The obtained results were depended upon the specific metaphors and the content of the communicated feedback. Conclusions were drawn about the applicability of metaphors, approaches and designs that worked successfully in e-feedback interfaces on the basis of efficiency, effectiveness and user satisfaction. The steps of the research conducted are briefly described below.

Literature Survey

Literature survey was the first step of the research that was conducted to review the current trends of multimodal metaphors, e-feedback interfaces, and the e-feedback (in itself). The literature survey is an in-depth analysis of the e-feedback systems that describe the current ways and techniques for understanding and implementing the system such as computer hardware and software design, recent statistics about the development and progress in e-feedback, basic principles used for spreading and gaining the knowledge over the e-feedback systems and the future trends. The literature survey also evaluates the current research trends in multimodal interaction and the e-feedback interfaces based on the multimodal interactions.

First Experimental Phase

The first experimental phase of the research compared the performance and efficiency of two different e-feedback interfaces. In the experiment, two groups of 20 users each were recruited to perform the experiment. One group acted as control and the other as experimental. The users in each group had to complete a number of activities (the same activities used in both groups) and answered questions about the content of feedback provided. The questions were based on recall and recognition and the difficulty increased from simple to complex. The control was presented with a typical e-feedback interface using text and graphic and the experimental group with an experimental approach that used multimodal metaphors such as text, natural recorded speech, and facial expressive avatars. The contents of the feedback types provided to the two groups were the same. The results and conclusions laid the foundation of the second experimental phase. In general, the role of the first experiment was to determine the facts and figures that were obtained from the literature survey and to form a base for understanding better the viability of the approach taken.

Second Experimental Phase

The purpose of the second experiment was to investigate the use of avatars as virtual tutors in e-feedback interfaces. Three varied e-feedback interfaces were selected and used to check and compare their efficiency and performance and usefulness to the user as well as to judge and compare their engagement with the feedback content. Among the three, the first was about talking face to face on the basis of facial expression and the second was based on voice expression of speech synthesis. On the other hand, the third interface utilized an avatar with body gestures and facial expressions. All the experiments conducted were evaluated by a group consisting of 36 users that were dependent on one another. The users working within the group were required to accomplish specific tasks.

Third Experimental Phase

On the basis of the derived results in the second experiment, a third experiment was conducted to check the effect of non-speech sound in an auditory message which was used to assist the half-body animated tutor when the feedback content have to be presented. Therefore, as an advanced and extended step of the second experiment, the third experiment made use of the earcons and auditory icons in order to investigate further communication issues of the auditory signals. This platform was called auditory-enhanced virtual tutor with body gestures (AABGP). The experimental group consisted of 24 members that evaluated the performance and usability aspects of the AABGP platform in term of the students' engagement (recall and recognition questions were used).

Conclusions and Guidelines

All the results obtained from the three experimental phases were compared and contrasted in order to produce a set of empirically derived guidelines for the design and implementation of e-feedback interfaces with multimodal metaphors.

1.6 Research Contribution

The research conducted in this thesis addresses both e-feedback interfaces and user interface design issues in e-learning interfaces. The results obtained can be briefly described in the following manner.

The strategy adapted in the thesis represents a new paradigm of reference that uses unique designs of multimodal metaphors to communicate information successfully in e-feedback interfaces in a way that is usable and enhances the students' engagement. Three different experiments were performed to analyse the role of the multimodal metaphors in enhancing the students' engagement and information communication processes of the e-feedback interfaces. All the results obtained agreed to the point that the use of multimodal metaphors not only makes the e-feedback interfaces more efficient with increase performance but they also boost the processes by which the users are able to get more and more knowledge from them when compared to the non-multimodal metaphors such as the text and graphics. The multimodal metaphors and their different combinations used in the experiments consisted of facial expression avatars, natural recorded speech and earcons, auditory icon and avatar body gestures.
The users are allowed to evaluate the facial expression and body gestures of avatar and face to face (video) and judge their performance within interactive e-feedback. The users are the allowed to rate a specific one and suggest them on the basis of their satisfaction and rating. The thesis also proposes a new way to integrate the earcons and auditory icons in the e-feedback interfaces so as to encourage the role of the avatars with animation and facial expressions. As a final step, the thesis proposes empirically derived design guidelines for the use of multimodal metaphors in e-feedback interfaces with engaged and better user performance.

1.7 Outline

This thesis consists of six Chapters and three appendices. A short description of these is given below.

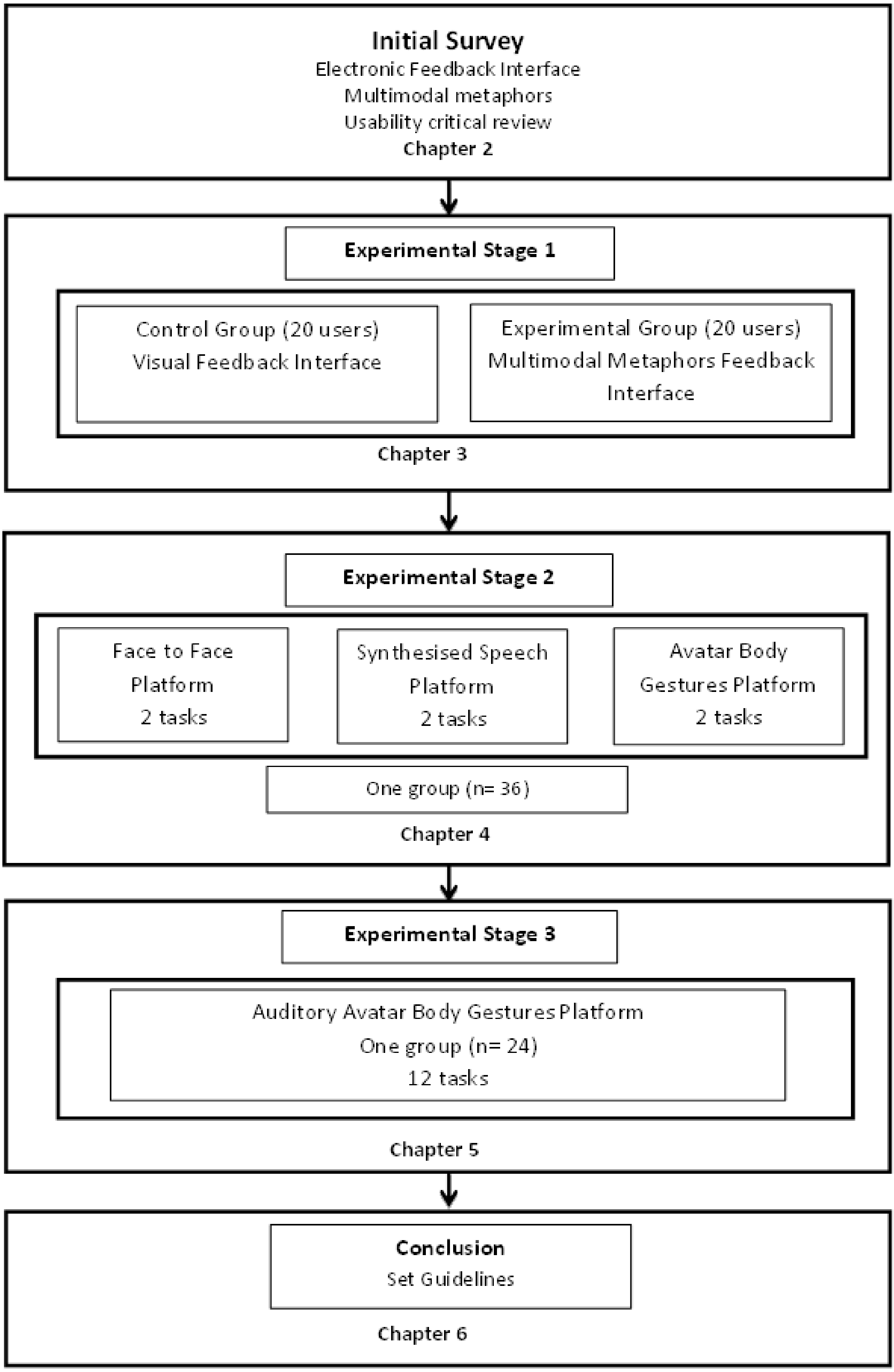

Figure 1.1: The outline of the thesis and framework of the research.

The first Chapter introduces the objectives and aims of the thesis and the research conducted as well as the method by which it is accomplished. It describes the outline of the thesis and the design approach in the multimodal e-feedback interfaces.

The second Chapter provides a literature review of the work already done in three categories. These are the e-feedback, multimodal interaction, and the e-feedback interfaces based on the multimodal interaction. The first category deals with through description of the e-feedback system starting from its definitions and highlighting its principles, usefulness, merits, and the changes it can bring about to the human society in the future in terms of the knowledge and information sharing. The category of multimodal interaction highlights the importance of the multimodal interaction and the benefits it offers compared to the non-multimodal interaction and its use in a number of applications by the work already done by other researchers with better and improved results. The third category directly addresses the design and implementation processes of the e-feedback interfaces using the concept of multimodal interaction.

The third Chapter describes the first experimental stage. It evaluates the use and performance of a multimodal and a typical text with graphics e-feedback interfaces. The experiment deployed two groups (control and experimental) working independently to evaluate the two conditions.

The fourth Chapter describes the second experimental stage that evaluated and compared the performance of three varied experimental platforms. These were a face to face platform in which the feedback was delivered by tutor in the form of video, the second platform used synthesised speech and the third platform delivered feedback using an avatar with body gestures.

The fifth Chapter evaluates the effects of using the non-speech sounds such as earcons and auditory icons on the performance of the multimodal e-feedback interfaces. This, in turn, also provides information about the way in which feedback content was presented by the virtual tutor using an avatar with body gestures.

Finally, the sixth Chapter summarises the research conducted in the thesis and discuses the results and conclusions. In addition, empirically derived guidelines were also produced to assist the process of designing and implementing multimodal metaphors in e-feedback interfaces.

1.8 Appendices

The appendices are briefly described below. They are used to support the material presented in the experimental Chapters of this Thesis.

Appendix A

This appendix consists of the questions used within the questionnaires of the third Chapter. Furthermore, it contains a frequency table showing the characteristics of the users, time taken to accomplish tasks, persistency in the answers, and the results of the user satisfaction questions.

Appendix B

This appendix presents the experimental tasks and questionnaire used in the second experimental phase and documented in the fourth Chapter. The appendix also presents frequency tables showing the data obtained regarding facial expression, body gestures and voice expression used in the experimental platform. These include time taken by users to complete tasks, successful completion of tasks and correct answers, and the results of the user satisfaction questionnaire.

Appendix C

This appendix consists of data associated with the third experimental phase. It contains the raw data about the ratings of the users to evaluate the non-speech sound and the raw data to check whether or not the answers to the learning evaluation questions were correct. Also, information related to the students' engagement tasks and the data showing the satisfied users are also parts of this Appendix.

Chapter 2

Multimodality and e-Feedback Interfaces

2.1 Introduction

Feedback is a vital component of effective learning. It facilitates students understanding of the subject matter being studied and provides them with guidance on improving their learning. Thurmond and Wambach [1] defined feedback as information exchange between a course tutor and a learner about course related activities and projects for the purpose of learning. Bellon et al. stated that *"academic feedback is more strongly and consistently related to achievement than any other teaching behaviour"* [2]. Feedback can improve a student's confidence, self-awareness and enthusiasm for learning. Effective feedback during the first year of university can aid the transition to higher education and may support student retention. Yorke [3] states that *"providing students engage with feedback, it should enhance their learning and improve assessment performance"*.

In the modern scientific and technologically advanced era, the world is often referred to as global village due to the shortening of the distances by virtue of the fastest and speediest ways of information exchange and data communication. All this is possible due to the advancements in the commuter hardware and software fields in addition to computer networking through the Internet. The computer hardware manufacturing discipline is entering the fastest era such as the billion transistor processors by the Intel Corporation launched several years ago. The synergies of these hardware and software lead to speedy ways of data and information communication throughout the entire world. A person located at one pole of the planet can now communicate with the one located at the opposite pole with practically no time delay.

The advent of the high speed communication devices in combination with the Internet technology has revolutionised the business, industry, trade, commerce, education, learning, and almost every aspect of life. Specifically, the availability of making the facilities of online and distance education has bridged the gap between the educational institutions and the individuals acquiring them.

A computer is used to provide feedback electronically in e-feedback systems and is also used by the students to know the areas of knowledge and evaluate various skills [4,5,6]. A number of tools from the information and communication technology (ICT) can be used to provide formative feedback. In accordance with the appropriate nature of the application such as conventional teaching in class room, the tutors can combine a number of methods and techniques by combining the conventional as well as electronic feedback methods such as type-written comments, feedback forms and the annotated work of students. Although such feedback is associated with students with in-print or email methods, the extent by which they boost the quality feedback is debatable because they combine the timeliness, motivation, personalisation, manageability, relationship to assess the quality criteria to assess the attributes of a quality feedback [4].

2.2 Benefits of E-feedback Interfaces

The report on Technology-enabled feedback [7] summarises the benefits of e-feedback such as the legibility of electronic feedback [8, 9 and 10], reduction in assignment turnaround time, efficiency in administration and paper efficiency [11, 12 and 13].

Other benefits have been recognised in a case study of a web-based course in primary care [14]. The specific advantages include: the use of hyperlinks and attachments in virtual communication which enable tutors and students to easily suggest additional relevant resources; copying others into a communication; joint feedback in specific areas; the 'senior common room' forum for staff where feedback can be discussed facilitates team teaching and contributes to the quality of assessment feedback.

The ICT tools can also be used in the e-assessment system to make the time and resources more efficient. The most challenging question today is that to what extent the technology can enhance the quality of feedback? The aspect of effectiveness [15 and 16] is particularly important in e-tools that are used to enhance the efficiency in terms of administration [16], access to documents, submitting the assignments and accepting them, dealing with deadlines, recording submission details, security of data storage, coping with the assignments distributions, making communication easy in the marking team, returning marking sheet, commenting on assignments, and list of class marks.

E-tools free up the time used in order to focus on quality feedback. We saw benefits in (a) using stock comments from a large bank so that comments could be individualised; (b) providing feedback online as it removes the problem of reading a lecturer's handwriting, and provides references to resources in the form of links to articles and books; (c) using electronic marking sheets returned to students by email.

The evaluation of Web PA system [17] also suggests numerous benefits for: (a) the institution (QA, records are stored centrally, flexibility and accessibility); (b) academic tutors (save time/reduce workload, transparency, confidence that the process is fair, reduce the number of complaints); (c) students (getting timely feedback, opportunity to reflect, enhancing skills such as communication, teamwork, monitoring, rewarding/penalising).

2.3 Pedagogical Principles of Feedback

The pedagogical principles that underline the design of courses make use of modern information and communication technologies. The key questions to be addressed are: What are these principles? How scientific are they? There seems to be a shift from a techno-centric approach to one that recognises the importance of the judicious application of pedagogical principles. The debate seems to centre around several issues. There is no universally accepted theory of learning. Another issue impacting on this debate is the relative importance of teaching and learning. Should there be a paradigm shift from teaching to learning? These issues are especially important in developing countries with limited resources.

The feedback that is provided at the educational institutions should follow some principles according to the teaching and students evaluating rules and regulations and are therefore called pedagogical principles. In order for the feedback to be effective and improving for the students, the feedback should be provided in time as a first principle [18]. The timely feedback allows the students (or other related bodies such as the business organizations, customers) to know their strengths and weaknesses and to remove the negative traits that may hinder their pedagogical development and progress. If the effectiveness is not observed, the feedback just becomes a criticism rather than allowing the chances of improvements to the students. Furthermore, the e-feedback system is designed to provide time efficient responses to the students [131] and if the feedback is delayed for some time, the basic purpose of the time efficiency would be destroyed.

Furthermore, the conventional methods of lecturing, examination, and grading are not regarded as the best and optimized in terms of providing the ease of conduction and the efficiency in terms of time. The best solution is to make them electronic. Although, it will not save a lot of time but certainly would save a lot of resources such as the paper, ink, avoiding accommodation costs, and all this can be done through the introduction of electronic systems based on e-feedback [19]. So, e-feedback systems for pedagogical purposes should take into account such considerations in order to provide the desired outcome.

Another pedagogical principle is that the feedback system should be adaptive and intelligent in order to achieve best possible outcomes [20]. As an example, if an instructor mistakenly sends the wrong feedback to a student, the feedback system should provide an opportunity to the student to acknowledge the received feedback and confirm it again with the instructor so as to trace and avoid the error. In addition, the adaptivity of the feedback system requires that all changes made within the feedback system recover the previous values and feedback. For instance, the feedback system of a University or college should replace the previous grades and evaluation criteria if updated from time to time so as to keep the students updated with the changes in such criteria and make them prepared.

Feedback enhances learning. The promotion of timeliness is accomplished through the use of a number of practices. The issues that had to follow were also discussed. It makes the feedback to flow in both directions, from the instructor to students and vice versa in order to replace the unnecessary and non-directional emails that carry the information about what the instructors want to deliver and what causes closing of the communication path way [21].

The instructors have the choice of choosing the answers of individual students and present it on a public display so as to initiate a discussion or have a feedback. However, as described [22], a number of pedagogical objectives are supported by this point of view such as the ability of the students to understand a topic and brainstorm. The comments can also be written on students papers in the available margins and mentioning the grade at the top. However, it offers a number of disadvantages such as the lack of space in the available margins for comments, writing comments by hands is a slow process, and sometimes handwritten comments are difficult to read. So, students may have difficulties in reading the comments and understanding their grades [21].

2.4 e-Feedback

One of the advantages of the information and communication technology in today's environment is the availability of the users to rate and rank an online service provided to them. For instance, as users are serviced by a company or organisation on the Internet (online) are often asked to rate the company's service. This is achieved by either eliciting their opinions or requested to select from a scale or menu of descriptions. Another example is when students study via a distance education programme of a University can also express their views on satisfaction about their degree of learning. This is called electronic feedback abbreviated as e-feedback. The online ranking, grading and commenting from the teachers to the students is also an example of e-feedback system.

An e-feedback system is one of the most effective ways to reference and track progress of the learning of the students [101]. E-feedback has the potential to enhance the virtual or online education system [109]. When all the classes and practicals are taking place online, it becomes increasingly necessary to provide online feedback instead of traditional paper based feedback. E-feedback can be used therefore in the response to the joint activity which includes both teachers and students [103].

The feedback received by the students can be made more efficient and productive by sending the comments of the instructors through email via Internet [11, 23, 24, 25 and

26] or any virtual learning environment because it does not disturb the privacy of the students and also enables them to react according to their temperament [28]. Other studies also suggest the beneficial aspects of the electronic or online feedback [8, 9 and 10]. However, Rowe and Wood [29] are of the opinion that it is necessary to re-evaluate the response of the students to the online feedback because it is more fruitful where students are isolated and not attached strictly with each other. There is a need for proper feedback on the performance of the students making use of online means compared to the ordinary methods of feedback because the online means have the problem of disconnection of textual communication. The feedback in online systems needs to be effective and efficient to overcome the problems of isolation and disconnection compared to the direct communication without any medium where such aspects are absent [124].

In the case of virtual communication, the students are unable to see the teacher, make an eye contact. Also, the presence of the teacher is not felt in a virtual communication as it is achieved by the exchange of messages sent to the groups. Bischoff [30] has categorised five types of communication messages by the teacher to feel the visibility of the teacher in online class rooms.

In order to avoid disgracing the self-esteem of the students, messages that threaten the confidentiality are best avoided [108] being sent to the entire group. So, if a student is not performing well, a messages needs to be sent to that student only. This is a form of feedback. The mechanism of automatic answering can help the teachers to let the students know that their assignments have been filed and read and preventing the students to contact the teachers repeatedly in order to ensure their work has been received and read. However, the students as well as the teacher try to make their participation more and more personal.

It is the feedback system in online classes that ensures the interaction is accomplished at the right time among the members of a group so as they share and learn the knowledge. All the students send their questions to the group and wait for the answers from the teachers and other group members. The most silent students are often the ones that discontinue the course.

The students prefer personal comments on their work [108]. If no feedback is given, students feel insecure about their progress in the course or feel they could get more attention. Some students interpret silence as though they are not on the right track, others just request attention, and others just want feedback as a kind of proof that their tasks were received by the teacher [112].

The lack of comments by others (mainly teachers) in a discussion group makes the person frustrated as all the topics cannot be described and discussed. It is also because of the fact that the teacher is regarded as playing the central and pivotal role in all online discussions and messages [104 and 117].

2.5 Style of E-feedback Interfaces

E-feedbacks and their applications come in different types [110]. Feedback forms of a word processing type which use standard techniques to provide formative feedback to students. Students can be assisted by providing well-structured format which would help them in the management and their interpretations of the comments of the feedback [120]. There are disadvantages in applying this particular method of feedback communication as it can lead to problems in getting the message across to the students [104 and 117]. There is a relatively new method to deliver feedback electronically using email [116 and 122] or attached feedback forms [133]. This is a simple and largely the most effective way currently to communicate feedback to students. This particular method of communication provides solutions to the problems of reaching the students as well as providing support to individualised feedback [129]. This feedback delivered by email also enables tutors to provide feedback comments to students through email [121 and 122]. But providing comments through email may be problematic to students because it may not be interpreted by them fully. And they may not be able to manage their emails properly, as opposed to the forms of structured feedback. Moreover, as email is very commonly used by the students, so they may not fully grasp the seriousness of the feedback comments given by the email [100]. But the IAMS (Interactive Assessment Management) is most suited to the task of managing coursework, which enables tutors and managers of institutions to better organise assignments and coursework in scheduling and delivery.

An e-Feedback system is a software with which the user interacts and it is an essential part of the process that leads to learning and student engagement [133 and 129]. It is designed according to the principles of usability, and those related to the experience of use in order to make the user experience more enjoyable, entertaining, engaging, useful and motivating.

The addition of new data types to the traditional text and numbers increases the possibility that more attention be given to the subject and can be computed more intensive and better storage. These opportunities may improve further if the data types are combined in an educationally appropriate [31].

Virtual Learning Environments (VLES) [126], exemplified by Blackboard and such other systems, are most suited to providing individual and generic feedback. They are also of great benefit and usefulness in providing comments in general. This type of form is also suited to communicating with all members of the course or the general body of students. Moreover, by this way the audio feedback can be provided in many forms and formats which would be highly suitable in making and delivering general feedback [128]. The audio feedback system [106] can provide the solution to many problems with the management of time on the part of staff and students, as well as providing feedback to all the students.

When a paper has to be written and revised, a specific learning style is utilised such as some of the students like to have feedback orally rather than through electronic means [124 and 128]. Others prefer to have a mental revision rather before doing work on papers. The type of the feedback given and received by the students also depends upon the cultural aspects and in this context it is the responsibility of the teacher to put enough materials in the e-learning environment so as to maximise the learning process. If examinations and exercises work towards learning, then other learning styles are also helpful to be used and considered for the learning process. Figures and diagrams can help in an examination towards possible answers. Carmo et alt. studied a number of activities that can help to support a varied set of learning styles [32]. The Felder-Silverman model was utilised to collect the information from a number of students using the ILS. The results showed that students with visual problems were uncomfortable in dealing with textual answers. Therefore, the learning environment should propose visual activities and ways for students to create solutions graphically [104 and 117]. When other dimensions of learning styles are taken into account the results differ. At every instant of time, participants were allowed to enter a command representing a screen change (for instance, changing a level in the tree structure, cancelling the screen, choosing a web page), the respective feedback was then an indication of the fact that the request was being processed [105]. The objective for receiving the feedback was the the reduction of the stress carried by the delay of the network to demand new pages. Every button in the indexing stages was leading to a screen change in 1-1 mapping interface.

So, each button pressed was followed by network download time. In the tabbing interface; however, only a few of the button presses were followed by network download time, since most of the button presses were for tabbing through the topic choices on the screen [32].

The exits styles of feedback are divided into three. The first one does not deliver feedback to users. In the second style (passive feedback), the feedback was an icon of a man running in a place, which did not present any indication of the estimated time to complete a request. The last style of feedback (active feedback) indicated to users the extent to which their request had been processed by presenting the running man icon beside a bar and the percentage of demand completed.

2.6 Student Engagement with Feedback

In this part we observe the consequence of students understanding that assessments and the associated feedback are for learning. This will only happen if the students are fully engaged in the procedure. Carless [33] proposes that "feedback is central to the improvement of effective learning" and goes on to discuss how students and lecturers hold differing point of views about the assessment, marking and the feedback procedure. The literature point out that frequently students do not get feedback or do not recognise what they have received it [112]. Receiving timely and meaningful feedback is essential. Some students also require help to understand or meaningfully interpret their feedback. Weaver [34] found out that students sincerely understanding the value of feedback but originate it to be too general or unclear. This, in turn, tends to deject rather than encourage them.

A feedback system for the students potentially offers several advantages that can be further used and worked on to make the e-learning processes efficient and capable of conveying more and more information to the students. This, in turn, would enhance the efficiency of the e-learning processes in terms of satisfying the students to acquire more knowledge and skills. Engaging the students with a feedback system certainly would offer a number of advantages. From the student's point of view, a feedback system will bring the clues for their evaluation in focus to them and they will use such evaluation and judgment in the future to do the best and avoid the negatives [129]. If students are allowed to have feedback about a learning activity (such as lecture), it can be made for the quality enhancement of the education and to maintain a standard.

First of all, using printed criteria for marking that is existing to the student prior to the assessment time [120] and then used for the subsequent marking assists both the student and the tutor [35]. Good practice would advise that the tutor obtain time to discuss the language used in the criteria with the students. This should be in the course orientation, with follow-up sessions as part of the module supervision. Stressing the value of module supervision facilitates both the student and the tutor, and is particularly essential in ensuring all students have fairness of chance. As Bloxham and Boyd [23] indicate, the student also has the precise to rise for explanation of points made.

Secondly, it is crucial to support self-assessment and suggestion by the student. These are meta-cognitive tools that will increase life-long learning and employability. Bloxham and Boyd [23] propose that if students carry out self-assessment subsequent to work has been marked it is unthreatening and should help the student in recognising the relevance to future work. Setting goals for the next part of work is as well suggested as part of self-assessment. Learning throughout reflection is a skill that takes time to build up, but as Boud [36] mentions, both the student and the tutor will be grateful for the long term benefits. Delivering generic feedback and requesting the students to decide which elements relate to their work is a further approach [37].

Thirdly, Weaver [34] proposes that tutors need an awareness of how students reply to feedback. By reviewing the language used and the messages offered, there are greater chances for the student to engage with feedback. Using a better balance of essential and positive feedback will help to make it more successful and help out in the procedure of feed-forward. It will as well support personal progress planning actions, particularly in circumstances of group and one-to-one tutorials [102]. Reviewing the feedback of other students allows the individual student to see their personal work and set their next set of aims. They should also have the opportunity independently to pose questions about these targets. As Bloxham and Boyd [23] indicated, this need self-confident handling by the tutor, in particular if the work has been marked by a partner.

Fourthly, the point views of stakeholders such as external examiners require to be taken into account. The function of the external examiner is to convey a stage of what Bloxham and Boyd [23] refer to as external accountability to assessment decisions, mainly in higher education. A most important part of this role is the moderation of scripts and courseworks to certify equality across the entire procedure, from assignment setting throughout to the provision of feedback to the students. This supports cross-fertilisation of ideas across institutions of higher education and encourages good principles in relation to the assessment/feedback procedure.

A group of 23 graduate students at Sheffield Hallam University belonging to four different faculties when interviewed about the effect of the feedback system towards their plans and attitudes showed that feedback is received by all the students and is very helpful in terms of planning for the future [38]. Results suggested that feedback shows both the strengths and weaknesses of the students to them or the positive and negative traits in terms of knowledge learning and knowing them is the only remedy that can be used in the future to enhance and boost the learning process by not repeating the negative points and remove the weaknesses. For instance the selected students were successful in improving their skills that were commented by the instructors to be improved and worked on. These skills include the writing the referencing, summarizing, and editing to mention a few. The feedback system for the students too offers a varied set of advantages that can be further used and worked on to make the e-learning processes efficient and capable of conveying more and more information to the students. This, in turn, would enhance the efficiency of the e-learning processes in terms of satisfying the students to get more and more knowledge. Engaging the students with the feedback system certainly would offer a number of advantages. From the student's point of view, feedback system will bring the clues for their evaluation in focus to them and they will use such evaluation and judgment in the future to do the best and avoid the negatives [127].

The feedback system can be applied to the grading criterion of the student [38]. The feedback system can positively motivate the students to struggle for the best and to overcome their weaknesses and enhance their strengths [39, 40, 41 and 42].

2.7 Usability evaluation in E-feedback interface

Multimedia learning is known [43] as the integration of text, graphics, audio and visual elements in one interface. A multimedia learning system interacts with the learner in order to communicate information that aids the learning process. Hansen [44] refers to these systems as interactive communication systems that depends on the creation and orchestration of forms of digital media including text, line drawings and animation, audio and video. The object of a usability evaluation is to assess the quality of a user interface's design and construct a basis for improving it. Usability evaluations and related activities help designers make better decisions, and do their jobs more effectively [131 and 133].

The product which has prominence is the system itself. A usability evaluation based on the final system is often denoted as a validation test. The most typical product that is used for a usability evaluation is a less complete but still an operational prototype of the system. This is often denoted as an evaluation test [134]. It suggests using very early design sketches, e.g. paper prototypes. The feedback also has different forms [101]. By far the most typical one is a traditional written report that presents a number of usability problems [127]. Other forms include meetings with designers, edited videos, re-design proposals.

Cooperative design processes are the best technique to engage all representative stakeholders, particularly representative users, in the design and development process early in the improvement series. When used in the early phases of the improvement series, feedback collect from these ways will contribute to the development of a user centred website with the least quantity of effort and cost.

The potential danger is that representative users can become so recognisable with the interface design that they commence to imagine more like design and development specialists and less like target users [45]. Cooperative design requires further time for stakeholders. Carrying all stakeholders together in a meeting could influence the input from users who may be reluctant to offer ideas or feedback when developers are present, either as they do not want to come out critical or are anxious of appearing uninformed.

2.7.1 Generating and e-Mailing Feedback to Students using MS Office

Tutors at Liverpool John Moores University (JMU) have used an MS-based system for generating and delivering feedback to students. The method uses Office 97 to produce feedback reports that can comprise the student's mark, position in the class, and a series of statements selected from a bank of comments, inputted by the tutor. The software also reports the regularity with which exacting comments were used. This vital information can be used by students to direct their learning, and by tutors to notify future teaching approaches. The process is matched to large classes and can make the process of returning feedback to students noticeably less difficult. The learning advantages of e-feedback were assessed by studying the regularity with which selected standard comments were used during the marking of normal feedback manner. These comments associated to errors made by students in their homework. The perspectives of students to the Electronic Feedback strategy was determined by their answers to a prepared survey that was done by 58 first year undergraduate students within the JMU School of Pharmacy and Chemistry. This was in addition to three focus groups, each comprised of three first year chemistry students selected at random. 43 members of staff were also demanded to produce their observations on the software after it was provided to them in a JMU training session. Additionally, 80 staff members were asked to respond to an e-mailed survey on the process, after they had some time to use the software.

Members of Staff who have used the software have found that the e-feedback method can make the marking process significantly less difficult, given that it eliminates the requirement to make notes on students' work with repeated hand-written comments. The package would be of particular use to tutors of large groups who find that they are not capable to return as much feedback as they would hope to using conventional methods. The two files that include e-feedback are password protected to stop the accidental overwriting of main code. So, there are partial probabilities for customisation. However, the user can have some control over the final form of the feedback sheets [46].

2.7.2 Video Technology for Student Feedback

There are several concerns surrounding the provision of assessment-related feedback in Higher Education [123] which in current years have been pointed out in the National Student Survey. In a survey [123], data from staff and students at the University of Reading were used to verify the main issues matched with feedback, specifically problems of time efficiency for staff, lack of engagement by students with feedback and issues with the timeliness and quality of feedback delivered. So it founded that the potential of technology, specifically video. This was demonstrated by enabling staff to create short feedback videos for students. The videos were hosted within a new online resource, 'ASSET', and were used to examine whether the use of this technology could increase the feedback experience for both staff and students. A pilot of the ASSET resource for general feedback provision found that it was considered beneficial by staff and students. The use of video was also used to determine many of the common problems of feedback in relation to value and engagement of students.

Feedback was a dispute for both staff and students for some time, even before the introduction of the NSS. Paper feedback has its restrictions [47, 48, 104 and 117] including problems of unreadable handwriting, and the possibility for misunderstanding of the written comments. Although more individual, verbal one-to-one feedback may not essentially be perceived by students as feedback; certainly Smith [49] has highlighted the concern that many students only see feedback the written comments on their coursework. With all the recognised challenges of delivering feedback to students and helping them to engage more actively with their feedback, a number of recent studies have looked at the educational use of digital technologies to enhance feedback provision. An appropriate technological application has the opportunity to support staff to reflect on their current feedback practices in order to present more detailed, clear and engaging feedback. Technologies may also offer additional ground that can help students to engage more effectively with their feedback.

Students noticed the video feedback as they did to the standard methods of feedback. However, the data from the student questionnaire demonstrated that students felt that they did take more notice of the generic video feedback in comparison to other forms of generic feedback.

A) Competence

Every video was taking no more than ten minutes except in one specific case where it took thirty minutes. The videos were also taking almost the same amount of time when other methods of providing the feedback were also utilized.

B) Punctuality

The major advantages of the video that were highlighted by the staff were the speed of producing the feedback and its accessibility by students as soon as it was downloaded. Also, the feedback could be played a number of times so students could understand it better.

C) Quality

The majority (75%) of the staff of the ASSET pilot was of the opinion that making use of the video was helpful in the ways they used to provide the feedback. Some of their direct comments include "I have more sympathy with those students who struggle with written forms of feedback, and try to affirm the principal things rather than lose these in the detail" and "it opened up my mind generally to alternative forms of feedback".

The results and data obtained in the experiments indicated that the use of video was helpful to provide an understandable feedback by the students. Furthermore, students can benefit more from the online programs by making use of the video technology [103] when they are away from the University or study part time. The study also shows that the use of video technology is applicable to both generic as well as individual feedback.

2.7.3 Students' Attitudes and Usage of Feedback via Audio Files

The study also takes into account the effect of formative feedback that students provide about the work related to academics in conjunction with the use of the audio files and the manner by which they implement the feedback in the learning environment. Fifteen students were contacted to obtain their opinions about the audio feedback related to their academic and written work. Twelve other students were also considered who had their written work and compared it with the feedback through the audio files. The rating of the students about the audio feedback system was better in terms of quality, understanding, depth and personal liking. The majority of the students were of the opinion that they would use the audio feedback to overcome their shortcomings for further improvement of their work with other teachers as well. However there were some issues with such type of feedback. The large size of the audio files and their compatibility with the email systems. Comment classification showed a greater confirmation on developmental aspects of learning within audio file feedback [50].

In addition, the response of the students with such type of the feedback system was very promising and all were in complete agreement that receiving feedback using this format was useful [106]. However, two students expressed a preference for audio as well as written formats. Thirteen students selected the audio feedback system as more effective than the written feedback system [104 and 11]. Also, twelve of the students found the audio feedback system to be of higher quality than the written feedback system providing more clear information and requirements asked by the teachers and instructors. Furthermore, fourteen of the students were considering quality as one of the important factors in implementing the feedback.

It is noted that the audio file feedback [106] was particularly high-ranking to students' learning as it met many of the requirements of effective feedback outlined in Gibbs and Simpson [51] as well as being detailed, promptly delivered (by e-mail) and can be understood by students. Audio file feedback may be clearer to students because they are more used to information being expressed in spoken words than as written words. This highlights the rising need for multimedia technology in their lifestyles and, maybe mobile phones and mp3 players especially [107]. It is also noted that 4 of the 15 interviewed students reported that they often did not read written feedback as the tutors' handwriting was difficult to read [104 and 117]. Audio file feedback reduces this occurrence.

2.8 Multimodality

In general terms, the literal meaning of mode is the way by which a certain work is accomplished. The term "multimodal" refer to accomplishing a task by making use of a number of ways all combined together. For instance, information that is used for the electronic feedback processes can be seen in the form of text, audio, video, and pictures. So, all these are different ways of representing the same or different information. Combining all these ways into a single communication in a synchronous or asynchronous manner results into what is called "multimodal" form of representing the information for the feedback processes. In this thesis, a term multimodal metaphor is used to indicate the use of auditory and visual metaphors to represent the information to be used in the electronic feedback processes and is called multimodal metaphors. The antonym for multimodality is the mono-modality and research shows that multimodality enhances the performance of the electronic feedback system compared to the strategies that use a single mode of representing the information, as will be described in the sections to follow.

What is the most important thing I should do if I want to make the interface easy to use? It is not "Nothing Important should ever be more than two clicks," or "Speak the user language," or even "Be consistent," [52].

It is very important for the user to get what they want from the computer through the interface. As we know people [53] deal and interact via their senses depending on each person. In computer sciences, the meaning of the term "modality" is ambiguous. In human computer interaction, the term usually refers to the human senses: vision, hearing, touch, smell and taste but many researchers distinguish between computing modalities and the sensory modalities of psychology. Sharon Oviatt offered a more practical definition, saying that multimodalities such as speech, touch hand gestures, eye gaze and head and body movement-with multimedia systems output" [54 and 55]. Nigay and Coutus said that "*multimodality is the communication that used by user in variety kind of senses channels to be delivered systematically*" [56].

A multimodal interface is a human-machine interface that combines multiple channels of communication between user and machine [57]. The examples most often used are the combination of gesture and speech (accompanied by a gesture of designation) and interaction with both hands on an interactive table. Therefore, we can conclude that multimodality is based on using tools to communicate between the user and interface, rather than using it as a one way channel as it is used in traditional or usual.
As is mentioned above, the user can only use one of the senses to interact with the computer monitor. By only using one of these senses, this will cause a lack of use in the rest. In addition, there are other reasons listed below that let us produce multimodal:

1. Data overloaded [58] means that the user gets confused when they are presented with a large volume of information which is often the case when only one channel of communication is used. The user usually uses one sense [59], but lacks the other senses cause data overload.
2. Improving performance of recognition-based systems [58] means the interface be used in a flexible way that produces an intelligence system. In addition, by improving a performance of recognition that will reduce errors [60] effectively.
3. Greater sense of immersion in virtual-reality environment [58].
4. Support time sharing and attention management of complex real-world [58].

Moreover, it is necessary to make computer technology more usable by people. The designer of an interaction system should have experience in psychology and cognitive science [55].

There are two groups of multimodal interfaces. The first group allows many user input modes together, such as speech and pen. This lets the user to rise up his experience power ability. The second group allows the user [58] to use a multimodal system output in terms of visual and auditory responses.

There are some guidelines for the development of multimodal systems, built on the analysis of the special quality that sensory channels have. Some concentrate on the effectiveness of the combination and integration of sensory channels with a high stage design standard. The guidelines which represent the main decisions and consideration involved in the process of designing a multimodal interface [58]:

1. "The selection of modalities: several reasons have been proposed for including multiple modalities in the design of an interface. Some researchers suggest that it should be supported to account for differences in user preferences, needs and abilities. Also, the selection needs to consider the tasks and type of information that the user needs to handle.
2. The mapping of modalities to tasks and types of information: the creation of natural mapping between modalities and the information and tasks to be presented.
3. The combination, synchronization and integration of modalities: This is an example that explains that one often-employed modality sequence is the use of an auditory alert, followed by the visual presentation of relevant information *"Cars use auditory signal to notify the driver of an upcoming turn, and a visual display then provides more detailed information"*.
4. The adaptation of multimodal information presentation: "*multimodal interfaces need to be flexible and take into consideration possible changes in the needs and abilities of the user, their tasks and work load and environment that they are operating*" [58].

The use of multimodality is supposed to be more useful than use a modal alone. These advantages support the user whose objective is to use the interface. The following are some advantages:

1. They reduce errors which may happened by users.
2. Allow the interface to be clearer.
3. It is easier to locate and accurate what has been going wrong.
4. Bring more bandwidth to the communication.

5. Add alternative communication methods to different situations and environment.

In terms of multimodal interaction: a multimodal HCI system is simply one that responds to input in more than one modality or communication channel (speech, gesture, writing and others) [55]. Classification of vision techniques for MMHCI according to human body: Large-scale body movements: there are three important issues in articulated motion analysis: (a) Representation (b) Computational paradigms (c) Computation reduction. Hand gesture recognition: according to psychology studies, there is a relationship between conceptualizing capacities and our linguistic abilities. Gaze is defined as the direction to which the eyes are pointing in space and is a strong indicator of attention [55].

2.8.1 Humanising Interfaces

Humanising interfaces has long been one of the fundamental purposes of research within the Human Computer Interaction. Humanization has two aspects, to make the interfaces easier and more pleasant to use and to make the interface more similar to humans [61]. The process of anthropomorphism provides interfaces to computer systems by providing some human-like characteristics. This is often achieved using speech output, the ability to recognise speech, through speech recognition, providing models of speech and kinaesthetic feedback, emotions (a project that is underway at the Human Interface Technology Laboratory in Washington), social intelligence and the possibility to recognise faces [62]. On another front, researchers are focusing on understanding of the technological systems necessary to integrate some or all of these different ways, how will the output of the computer and especially what are the patterns of interaction that become predominant use of these human-like interfaces [63]. To clarify the basic concepts and some of the problems outlined above, we'll use the general thesis of the Human Computer Interaction, according to which, there are two participants in the interaction, man and machine, which are seen as two separate agents. They are physically separated, but are able to exchange information through a number of channels of information.

The diagram of Figure 2.1 illustrates the exchange of information between man and machine.

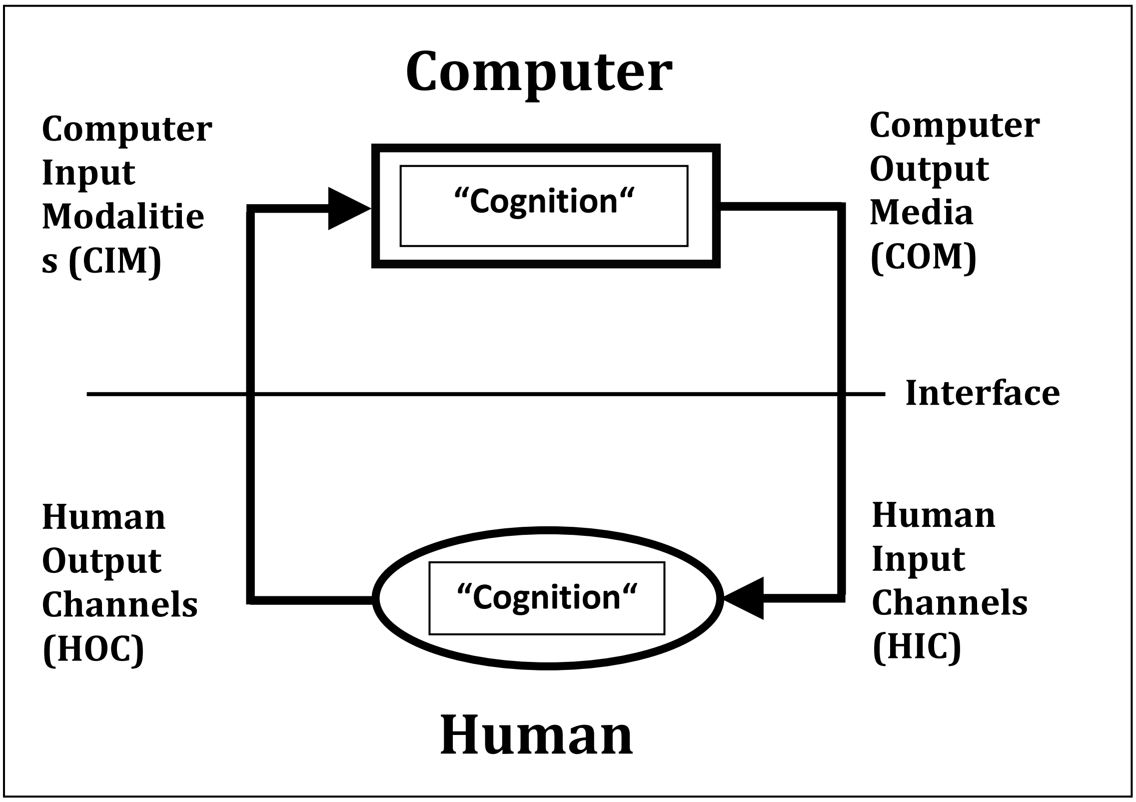

Figure 2.1: Simplified model of the processes involved in the interaction.

As we saw in the first chapter, there are two basic processes that involve the human user: the perception and interaction. Compared to the perceptual process, you can make a distinction between the human input channels (Human Input Channels, HIC) and the average output of the computer (Computer Output Media) [64].

At this point, inside the two agents, can be identified a cognitive component (for humans) and a computational (for the computer) that process the information input and prepare the output [65]. Within the processes of perception and interaction that take place in a multimodal interface, you can define different levels of epistemological observation, relevant to both the man and the machine.

2.8.2 The concept of (Multi)-Mode

A mode can be defined as a perceptual process using one of the three channels of perception human. There are three modes: visual, auditory and tactile. The human visual mode is precisely the use of sight, compared to the optical mode of the computer. The auditory mode is related to the sense of hearing, with respect to the acoustic mode of the computer [66]. The tactile mode, is experienced with the sense of touch. From the point of view of the computer, the methods used are precisely: the mode optical (optical is the theory of light and the adjective optical refers to physical quantities, rather than physiological variables, as opposed to visual); acoustic mode (the 'Sound is the theory of vibrations and oscillations in an acoustic medium and the attribute refers to the physical rather than physiological, as opposed to auditory) [67]. How to touch the computer, even if differentiated in English literature in haptic and tactile, is not distinct from that of humans. The three methods presented are those that are relevant in multimodal interfaces, even if other perceptual modalities, such as the sense of taste, smell and balance, which will not be discussed here. The sense of balance seems to be interesting in applications of virtual reality.

When more than two modes are involved in a process of interaction, it is called multimodality. It beats on the keyboard commands and move the mouse (or some other instrument), click in certain positions and hear the reactions of computers (e.g. sound of a warning) [68]. A narrow meaning of multimodality identifies only those interactions which include more than one mode both input (process of human perception) is in the output (control process) in the circle interactive, and the use of more than one instrument is as input and as output. Thus, for example, the combination of feed-back visual, auditory and tactile inserting words from a keyboard is explicitly excluded from multimodality, while the combination of visual and auditory output products from the monitor and a speech synthesizer, when for example the system alerts the user that has made a mistake, really is a multimodal event (in this case, bimodal).

2.9 Visual Display

A visual display is a channel which is used to show objects generated in the computer through an interface. The vision sense is used to view an object at a distance and can be either text or graphics [56]. In visual modality, the designer is considered to use natural graphic such as more images and diagrams [69]. For example, Rational Rose [70] software which creates a visual modal by converting a user’s class diagrams to class directly in UML language. Basically, there is a good effect of using visual modal because it allows the interaction between the user and the interface to be easier and smoother. However, using more pictures and graphic in the interface might lead to do overloading and confusion at the user. So, making the interface easier and simple is an object to improving the interaction with the user. With visual displays, the user must keep his/her eyes on the interface to concentrate on what is going on. However, auditory channels will make a contribution to other senses.

Visual display is responsible for representing the desired information in a manner so that it can be seen visually and it is accomplished through a number of ways such as by designing a web page (the world wide web) and representing the information on it, making the graphs, tables, pictures, or presenting the summary in the pictures or text form, all are the ways by which the useful information can be displayed to the desired individuals. In fact, using the visual displays are the easy, simple, efficient, and time saving ways of representing the information [71]. However, such strategies are completely useless for individuals possessing visual disabilities and need specially designed ways and methods for information communication and understanding of them.

2.10 Auditory Modal

This model deals with the representation of the information in a form so that it can be easily interpreted and perceived by the human auditory senses. The auditory model is mostly represented by the speech.

2.10.1 Speech

A speech modal is a channel that used to represent specific information to users by using voice [72]. It has been established to use sound in auditory modal as alarm. Actually this is based on using a signal to give attention to user that there are something wrong or right. This was first applied or used by [73] and [74]. As was mentioned in previous section about overloading of information, this may be useful for systems having a limited screen area. Consequently, the presentation of some information in sound will help to reduce the text and graphic in the interface [72]. In addition these will utilize other senses such as hearing and eyes. Mountford and Gaver [75] recommended that voice is helpful that because the sound is well-known and normal for conducting information which is used in people's daily life. There are many ways to use sound, like supporting an object which is based on visual modal where the sound can be used for background instructions to guide the user [76]. An example of this, is the car navigator, the sound is used to tell the driver what is drawn on the map. It is very important to have some knowledge about the perception of sound [72]. This explains the links between the features of voice that goes on inside the ears and the feelings which generates in the auditory systems.

2.10.2 The Recorded Speech

The speech comes first among the metaphors that can be used easily without too much hardship and struggle for the human computer interaction. This is so because a simple microphone followed by an analog to digital converter is used to make the interaction of the speech with the computers. Recently, computers use speech recognition software and algorithms installed on them that input the speech signal of the human and convert it directly to the digital form understood by the computer [77, 78 and 79]. The speech can be recorded or unrecorded.

2.10.3 Speech Synthesis

The synthesised speech, as the name indicates, is artificially generated in the laboratory environment and it does not represent the natural human voice. The speech formed and synthesised in this manner can be used in a number of applications such as by applying to the input of different machines. However, the quality of the speech produced in this manner is lower than the natural speech and most often the degree of comprehension is less than the natural speech. The extent of naturalness is rare in this form and can be differentiated form the natural speech of the human easily.

2.10.4 Non-speech

Non-speech sound metaphors in auditory displays are non-verbal cues that transmit information about objects in the computer interface. These can be made of digitally recorded or synthesised musical instruments, everyday sound effects, or electronically produced pure tones [80, 60 and 81]. Published in 1989, the special issue about non-speech audio of the Human–Computer Interaction journal set a model for auditory display theory and practice in computer interfaces [82]. An additional technique of non-speech sound applications in computer interfaces concerns the use of earcons (abstract musical tones that convey information about actions, events, or objects at a computer interface). It is important to note that the mappings between the information and the earcons must be learned, because the sounds do not have a direct meaning or do not provide direct cues about the represented information [60].

The non-speech metaphors do not refer to the normal speech but in fact they are non-speech sounds that facilitate the interaction of the users with the computer systems. They also not only increase the performance of the users but they also increase the usability of the interfaces.

The ways of addressing and communicating the information about a product makes the user to be bombarded with an excess of information also called as overloaded with information and this situation is cope with the introduction to new strategies and techniques such as by making use of the multimodal interaction and metaphors [116]. For instance, a MCKMS mode works to communicate the information and knowledge about the product by combining speech, environmental sound, and metaphors based on the rising pitch. As another example, the ACKMS system merges the speech, earcons, and avatars with the expressions of the face to communicate the knowledge and information [115]. So, the use of multimodal metaphors allow the users to save their time and have access to the desired information in an efficient and speedy ways compared to the way of communicating information using text and graphic in a combined manner. Although the use of audio-visual interfaces offered a batter choice to the users searching for the information, it had severe problems when communication of the audio messages took place earlier during the experimentation phase. Later when the users had experiences with the system, the performance of the system guaranteed the user's satisfaction. It was also found that the different components of the multimodal metaphors had different performance in terms of communication the knowledge. For instance, the performance of the auditory icons was superior compared to other components of the multimodal metaphors in terms of communication knowledge through sounds having resemblance with the external sounds in the environment. Earcons, on the other hand, came out to be not as helpful as the auditory icons to communicate knowledge like auditory icons yet they proved to be good for communicating knowledge and information having low range of values, such as the rating systems. Furthermore, experiments show that recording and synthesising the speech metaphors and combining them communicating the respective long and short messages is a promising idea with useful results. Also, models for combining the recorded speech with other modalities have shown improvement in performance of the

CKM system with enhanced and increased interaction of the users with the system [114]. In summary, it is valid to say that it is better idea to use the multimodal metaphors for communicating the knowledge and information about the products and bring improvement in the E-CKMS systems and its use which can be verified from the research already accomplished in the disciplines such as software engineering, Internet browsing, and E-commerce[113].

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2.10.5 Auditory Icons

The interest of passing on information in the computer interfaces through usage of sound is rising. One such method is to use auditory icons, these are the methods of sounds that occur naturally [157] which then could assist in providing information regarding source of the data. According to [158] the definition of auditory icon is "everyday sounds mapped to computer events by analogy with everyday sound producing events".

They offer a way that sounds natural in representing data that is dimensional and also the objects that are conceptual in certain computer system. The auditory icons allow the data to be categorised into varied groups, by using a single sound [159]. One of the most significant advantages of using these is that the sounds used in them are those which people hear in their daily lives, and associate them with certain action [160]. An example of this in the virtual world would be hearing sound of an object that crashes into wastebasket when deleted, or marked for deletion.

This category of auditory icons is like the sound effects which complement the visual events with an appropriate sound in a computer system. Yet, there purpose is not just simply to serve as entertainment tools but also to convey very significant information regarding the events taking place in computer system, this allows the user to listen to the sounds from computer as he does from everyday world.

Systems like EAR (Environmental Audio Reminders) which plays variety of the non speech audio cues for offices and the common areas within EuroPARC in order to keep us up to date regarding the various events taking place around its building, ShareMon which utilises the background sounds In order to spread awareness, Sound Shark: the sonic finder is useful when incorporating the auditory icons in an interface that is well known and used often, the simplicity of it leads people to underestimate the functions auditory icons are capable of. For this reason, Gaver and Smith [161] demonstrated auditory icons used in a large-scale, multiprocessing, collaborative system called SharedARK, and called the resulting auditory interface SoundShark [162]. Moreover, source and sound analysis combined all together to produce a synthesis of auditory icon. However [163] said the analysis of source and sound are not usually significant although that [163] has introduced an ad-hoc synthesis to let user recognise sound instead of the analysis of source and sound.

These systems display the extensive range of functions performed by the auditory icons. These include provision of information regarding the user's actions, the possibility of new actions and also the object's attributes that are not visible in system. They also provide the background information regarding the modes as well as processes in a system that is more complex. Navigation in the complex systems is supported by repetitive or the continuous sounds that vary according to distance, thus serving as the auditory landmarks. Finally, these icons can also work with the graphic displays which support the smooth flow in both cooperative work and individual work.

2.10.6 Earcons

The earcons are non-speech short musical sounds that are used in the interaction processes of the computers and human and their job is to convey and communicate the information about different objects, operations, and the interfaces involved within the human computer interaction. Another definition of earcon is "An earcon is defined as a combination of musical notes, called motives, or even a single one, with specific characteristics, such as changes in duration, tone/timbre and loudness" [84]. Earcons are associated with either objects or actions presented in a computer interface. Because earcons make abstract associations with data, users must learn them in an initial training process [83]. Earcons related with device palettes were examined in a computer drawing program to emphasis its usability [85]..They are constructed from the short term musical tones and can be further made shorter and in this way they can be used to convey and communicate the information about the complex systems. A number of experiments have been accomplished in different domains to check the information conveying contents of the earcons and all the experiments have proved that earcons are the best in terms of communication the information within the sound signals.

2.10.7 Sonifications

Sonification is defined by Kaper et al. [86] as the "faithful rendition of data into sounds". It has been created by Bly in her studies, about multivariate data analysis using sound features of synthesized tones, pioneered the use of non-speech sounds in the computer interface [87]. During the 1980s and part of 1990s, however, there was a lack of research on non-speech sounds in human-computer interaction in visualisation aspect [83]. One reason for this was because of the limited developments in audio-related technology, especially those developed in early personal computers [88].

2.11 Avatars

An avatar is a new function that is used in the interface to interact with a user and represents a real human beings face as a graphical image of a user [132]. The avatar can be either the head of a man or women, or a whole body. So it is an image which represents the expression. The idea behind the avatar is to simulate a user by using an actual human. When the user is in front of the screen of computer, would not be boring, he/she wants to be like 'human-computer'?. Actually, the avatar combines all model senses "visual and auditory" in 3D. The link between the user and the data is the avatar [89]. The avatar is used in many fields. As we can see, it is used in computer games, ATM, advertisements and e-learning. It is noticed that people spend a lot of time playing games because they find there is something interacting with them. Also, in e-learning, it can be used as a lecturer to teach the students and to represent information in human activity [126 and 130]. In addition, in business, it can be used to give information about a new product with brief explanations. The avatar is not a video clip; it is built on interactive elements. That means, the avatar communicates with the user as reaction to the user to what he/she requests [89] in a clear manner. Recently, the avatar became commonly used in many aspects develop interactivity - learning engagement and cultural factors are important design considerations [89].

It is another kind of the non-speech multimodal metaphors that combines the use of audio and visual senses in interaction of the humans with the computer. Since it combined the two senses, all the advantages of the audio and visual metaphors are combined in these metaphors. In general, avatars can be classified as abstract, realistic and naturalistic. Abstract avatars are cartoon-like interactive characters with limited animation. The help avatar embodied in Microsoft‘s office application is an apparent example of these avatars, designed to provide the users with helpful information during the preparation of their documents [134 and 126]. Realistic avatars offer real representation of humans being generated based on captured static or video images and are used in several applications such as games, movies and teleconferences.

2.11.1 Facial Expressions

People usually communicate by using their senses to enhance their objectives. This communication is either face to face or face to non-face [119]. Technology has been developed which uses carton-like and human-like features in interface application to give more realistic environment [90]. Facial expressions state feelings and emotions by sending a message to others about something. Beswek [91] stated that control of non-verbal communication and control visual communication are classified as two groups for facial expression parameters. In control visual communication, the character’s lip and mouth form are used to reveal visual expressions by producing a normal mode of mouth form while talking. In contrast, in control non-verbal communication, head movements and facial articulation are consumed [92]. There are many studies which have investigated how many expressions human beings use. This research focuses on the reaction that can be got as a result from the user. For example, Theonas et al [93 and 94] observes the facial expression of three lecturers in a lecture theatre. Beside that, the reaction of students was also recorded to see if they increase their attention or decrease it. The results of the experiment indicate that when the lecturer is more active and shows his /her smiling, this will result in positively on the students and they will be more excited in the classroom.

2.11.2 Body Gestures

Non-verbal messages communicate a significant amount of information [133 and 119]. Although body gestures are culture dependent to culture, strong messages of emotion and attitudes are communicated [95]. Body gestures in avatars are used to enhance speech and add emphasis [125 and 133]. By using our hands, heads and feet we can represent a very wide range of signs, signals and movements [95]. For example, instead of calling someone, we can use a hand to point to him/her; also nodding the head means it is agreed for something and so on [125]. However, sometime some gesture confuse, so the culture and the context define the meaning of gesture [95], such as a person taps his temple with a forefinger that may be mean intelligent or crazy. Basically using body communication is highly recommended because it sends a strong message that it can emphasise personal feeling or a specific object.

2.12 Multimodal Feedback Critical Review

Multimodal analysis refers to the use of audio and visual metaphors within the interaction processes of a user with a system [111]. In the context of e-feedback, the student's responses to the audio and visual feedback often lead to encouraging results in terms of understanding the subject and enhancing the learning and its efficiency [96]. It was demonstrated that arts-based students are good in terms of selecting their subjects that help them later in boosting their interests. However, activities and actions related to writing contents are not as actively participating by the art and design student compared to the activities involving use of the audio and visual senses [104]. Also, students were more comfortable with accomplishing activities using the audio and visuals marks in order to remember lessons and understand the concepts rather than relying largely on text that is often cumbersome to read [104]. Furthermore, the word blindness condition also called as dyslexia is a condition in which a student is unable to differentiate among different kinds of words and this difficulty can be removed by using audio feedback [102, 107, 108 and 110]. This indicates that a written feedback is not always helpful and that the use of the multimodal metaphors (audio and visual) can potentially have a better performance in terms of efficiency at least in some cases.

The use of multimodal metaphors also allows users to read selectively by browsing through the audio and visual materials by skipping parts of little interest [96 and 111]. In addition, the learning styles of students often differ. Therefore, the use of multimodal metaphors enhances the learning capabilities of students by providing different means of learning such as audio, video, mp3, screenshots [106, 107 and 110].

The concept of multimodal feedback has been utilised to help getting the small targets in the realm of graphical user interfaces during the human-computer interaction [97]. The feedback was provided in three types called the non-speech, tactile, and the pseudo-haptic. In the tactile type of the feedback, the simulation was performed by making use of the vibration and the sticky conditions were performed by dynamically reconfiguring the display controlled by the mouse when the cursor was used to enter the target. The final conclusion drawn indicated that for all the three types of the feedback systems, the target time was reduced as long as the targets were located closed to one another rather than being at a reasonable distance.

The concept of multimodal feedback was utilised in controlling the automatic zoom based on a tilt controlled speed [98]. This technique can be used to navigate the documents on portable devices such as laptop and cell phones. The processes such as the browsing and targeting are accomplished by making use of the sonification process which generates an audio based feedback about the structure of the document under observation and examination. The proposed design was implemented with a pocket held PC containing a text browser and capable of communication with the accelerometer and headset, the result showed that the feedback given by the corresponding audio contained a lot of information about the interaction methods on the basis of the motion and allowed a varied degree of freedom to the user to engage and accomplish other tasks as well [133, 129 and 128]. Furthermore, a text file was used to locate the number of the desired elements to confirm the results and conclusions.

There is a great need to have a presentation system that structures the data in such a manner that it is presented well to the students [127 and 118]. The presentation data is often in the form of multimodal metaphors and enhancing the ways of presentation would certainly help the students in understanding the presentation better. The work of a master thesis also argues in the same direction [99]. The thesis proposes the design of a presentation recording system which is based on multimodal metaphors. The obvious advantages of the proposed system is that it can be used to save the presentation and students can access it anytime. For example, a student can play the audio or video files of the presentation at different times. The lecture can be listened by the student repeatedly until the underlying concepts are fully clarified. A specific presentation is recorded and managed. All the contained information can be saved and retrieved in a number of multimedia formats. Special software is used to perform all these actions for the proposed system [128, 129 and 126].

The tactile feedback system is one of the most efficient systems that are used as a multimodal feedback elements and components. Today, a number of communication and information technology devices are there within the market based on this feedback element of the multimodal feedback process [81]. For instance, the touch screen devices are good examples that make use of a number of senses (multimodal) such as the visual and touch to accomplish different tasks as desired. In fact the usability, performance, and satisfaction of the different interfaces can be enhanced and increased to a significant extent by making use of the multimodal feedback. More specifically, the multimodal feedback is required with greater expectations and performance and efficiency enhancements in circumstances that demand high attentions and care like driving a car or monitoring a complicated and diverse system [11]. The work specifically highlights the performance of the multimodal feedback through the applications of the touch-screen.

2.13 Summary

This Chapter describes the importance of the multimodality and the need for multimodality. Multimodality means incorporating a number of senses such as the visual, audio, and video (visual plus audio) into a single and unified form of communication in order to make the user interaction more meaningful. The speech can be natural or synthesised. The use of natural speech is more meaningful compared to the synthesised speech. The earcons are non-speech short musical sounds that are used to communicate information about different objects, operations, and other events in the interfaces. They are constructed from short musical tones and they can be combined and build up in a way that they can be used to communicate greater volumes of information in a user interface.

The e-feedback should be in such a manner that it should enhance the learning capabilities of the students as well as ease the process of human-computer interaction.

Recently, the e-feedback systems using the multimodal metaphors have gains significant importance.

It was clearly revealed that using one kind of channels to present the feedback on the e-feedback interface will lead to disengagement and decrease the usability of the interface. The experiments platform the in next chapters will demonstrate the sufficient solutions to engage the users with interface of feedback and also, reduce the time that spent to get the feedback and satisfied them.

Chapter 3

The role of multimodal metaphors in an e-feedback interface

3.1 Introduction

The communication between students and tutors plays a big part in the research today. This communication is performed using technology which is used in most e-learning systems. For example, such communication is e-feedback which is comments concerning a student's essay or coursework. It becomes clear that an information overloading of comments occurs [153] by tutors on an e-feedback interface and that this is related to the way that feedback is presented [154]. Moreover these problems cause a certain weakness in the performance of learners [156]. Also, it leads to student's disengagement [152] with the feedback and the learning process. Human-computer Interaction is concerned with the usability of interfaces; in particular those employing multi input modalities, such as recorded speech, text and avatar, to communicate information between the user and the interface. There is, however, evidence to suggest [151 and 155] that multimodality could positively contribute in a general E-feedback interface, particularly from the point of view of learning. It is essential to deliver feedback in an effective manner to engage students with learning objectives. Due to the lack of research on using multimodal metaphors to increase usability of the feedback interface, it is vital to investigate the use of multimodality to engage students with feedback. This Chapter presents the first experimental stage of this research. The aims of this experiment are to investigate and compare the effect of using speech with simple avatar and text, graphics and colour, and textual essays with some graphics in an e-feedback interface. Also, it aims to measure usability in terms of efficiency, effectiveness and satisfaction. A typical feedback on an essay has been written by an instructor. A platform has been set up to examine the aims described above. There are two different interfaces which present the same content but communicate the content in different ways. The first interface: Visual Feedback Interface (VFI) uses text and graphics to communicate the feedback to users. The second interface employs multimodal metaphors based on text, colour, natural recorded speech and avatars to communicate feedback to users.

3.2 Objectives

The objectives of this experiment are:

1. Investigate the impact on the usability of combining recorded natural speech and speaking facially expressive avatars.
2. Evaluate the extent to which the addition of the multimodals could affect the user's learning performance and engagement.
3. Evaluate efficiency, effectiveness and satisfaction.
4. Evaluate the effects using different interface circumstances with different tasks complexities (easy, moderate and difficult) and tasks type (feedback classification code).

Overall, investigate the usability aspects and student's engagement of e-feedback interface that combine recorded speech, expressive avatar and text and graphics to keep student engage using feedback.

3.3 Tasks

There are tasks of the experiment are listed below.

1. Formulate an experimental hypotheses depending on condition that are used.
2. Creating an experimental and a control platforms in an independent study to examine, evaluate and compare the two approaches based on measurements of usability and performance.
3. Empirical evaluation of the control group that involves the visual interface and experimental group that involves the special and unique designs with the multimodal metaphors.
4. Measure efficiency (time spent in completing task). The time by users to complete each task for each platform.
5. Measure effectiveness (correct task and student's engagement). Each task has number of questions; by assessing the correct answers to these questions, effectiveness and student engagement are measured.
6. Measure user satisfaction by enabling users to assess and rate the interfaces. Analyse and critically evaluate the results.

3.4 Experimental Platforms

3.4.1 Visual Feedback interface (VFI)

The First experimental stage is based on two different interfaces. The first interface (Figure 3.1) is the control group: Visual Feedback interface (VFI). It uses traditional feedback written by an instructor. The platform however simulated this paper-based feedback electronically. The VFI contains symbols to denote certain feedback items; for example, a cross symbol represents errors, and a zigzag to communicate confusion.

Users of this platform would browse their work with the annotated feedback and will follow up symbols in order to read the comments. The student in this interface uses visual sensory modality to receive feedback; all feedback items are communicated by text or graphics. When the student wants to read any suggestion regarding their feedback then he/she looks at the symbol that refers to the suggestion and reads the associated description. Users need to identify the relationship between using symbols and comments in order to successfully interpret the e-feedback received. Consequently, it is the relationship between symbols and their associated meanings that makes the connection meaningful.

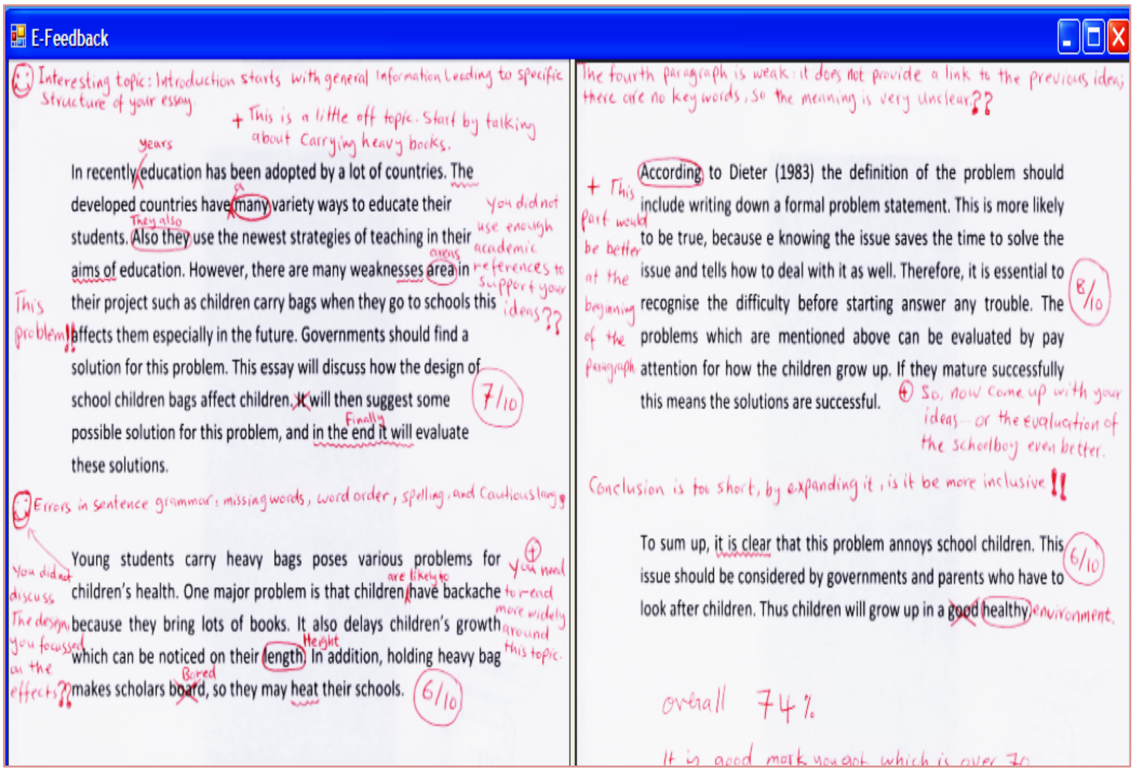


Figure 3.1: The sample feedback used in the control group interface (VFI).

3.4.2 Multimodal Metaphors Feedback Interface (MMFI)

The second interface (Figure 3.2) is the experimental group: Multimodal Metaphors Feedback Interface (MMFI) (Visual, Audio and Avatar). The experimental platform provided multimodal feedback so that each symbol or text comments were replaced by a speaking expressive avatar and colours were used to highlight different types of errors. Additional graphical illustrations and textual explanations were also provided in a colour coordinated manner. Errors were denoted by highlighted colours and comments were illustrated by using natural speech, text and an avatar with expressions. The feedback is presented using a specific design that utilises multimodal metaphors. All feedback classification codes are designed to be on one horizontal panel as buttons. In addition, there are three segments on the interface designed to be communicated using audio, visual and avatars.

Both interfaces were evaluated by users to observe and examine usability in terms of efficiency, effectiveness and satisfaction. Specific tasks were designed to determine the effectiveness and efficiency of each interface. The successful task completion rates were used to determine the most effective interface. The completion of tasks in the shortest time were used to determine the most efficient and usable interface. User satisfaction was measured by obtaining the preferences and views of the users about the control and experimental interfaces.

Figure 3.2: This is an experimental group (MMFI).

3.4.3 Implementation of Modalities

Natural recorded speech was used in this study to state the classification of feedback code. The content of feedback delivered consists of different parts such as *Engage Thinking* and *Further Suggestions*. Secondly, the text and colour on the left of the interface is a feedback type that communicates *explain ideas* or *comments*. By clicking on any buttons of feedback types and moving the cursor on highlighted text on the main article, the feedback text appears on the Text box. Thirdly, facially expressive avatars with expressions such as *happy*, *normal* and *sad* were used. CrazyTalk 6.0 was used to create a human-like expressive avatar. This is a multifunction program that allows editing and manipulation of images to produce the facial expressions of neutral, happy and sad.

3.5 Hypotheses

By integrating natural recorded speech, text and facial expressive avatar together will influence the usability of e-feedback interface and user's engagement for the content of the feedback that presented by e-feedback interface. Consequently, the following hypotheses are formulated:

H1 The multimodal feedback interface will demonstrate better usability in term efficiency, effectiveness and satisfaction of E-feedback systems.

H2 The multimodal feedback interface will help to engage students with feedback more effectively than the traditional e-feedback interface. The integration of multimodal metaphors in the e-feedback interface will help the user to engage with feedback more than a traditional e-feedback interface.

Efficiency is measured by the time spent on completing each task in both interfaces; so, to determine which interface is more efficient, the mean time of the overall time spent to complete the required task is taken. Effectiveness is measured by looking at the percentage of tasks completed correctly in the multimodal metaphor interface and visual interface only. Satisfaction is measured by looking at users responses to standard questions at the end of experiment to compare the highest percentage of satisfaction. Meantime the engagement can be measured by looking at the percentage of correctly completed tasks.

Experimental level	VFI		MMFI						
Modal / Items	*Text*	*Graphic*	*Text*	*Graphic*	*Synthesized speech*	*Earcons*	*Auditory Icons*	*Recorded Speech*	*Avatar*
Errors	✓	✓	✓	✓					
Correction	✓		✓	✓					
Comments	✓	✓	✓	✓				✓	✓
Explain Ideas	✓		✓					✓	✓
Engage Thinking	✓		✓					✓	✓
Suggest Further	✓		✓					✓	✓
Marks	✓	✓							

Table 3.1: The allocation of metaphors in the control and experimental versions of the platform.

3.6 Variables

The following describe the variables that are used in this work. Independent Variables (IV) were used to communicate the e-feedback. This was produced in several ways, such as text and graphic in the control group and natural speech, text and simple expression avatar in the experimental group. Also, task complexity levels are considered as independent variables and were categorised to three levels easy, moderate and complex. The Feedback Classification Code was also considered as task type and served as an independent variable. The Feedback Classification Code are categorised into three groups based on that each group contains each modal which are used in first experimental stage. The First type consist of *errors*, *corrections* and *comments* and is referred to as Feedback 1, the second type consists of *explaining ideas* and is referred to as feedback 2 and the third type consists of *engage thinking*, *Further suggestions* and *marks* are referred to as Feedback 3.

Depended Variables (DV) were used to measure efficiency (time spent to complete tasks) and effectiveness (correctly completed tasks).

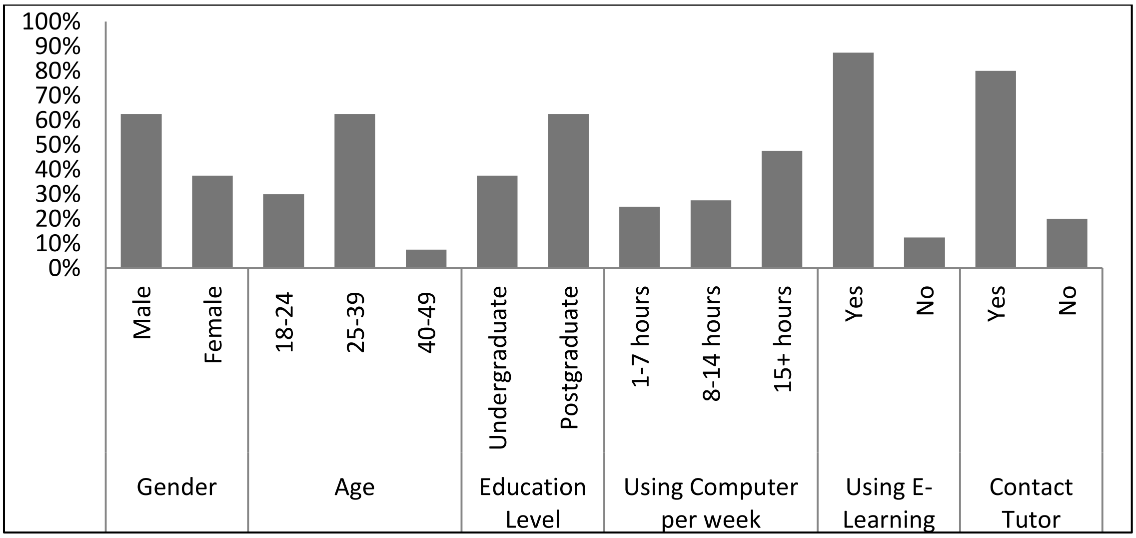


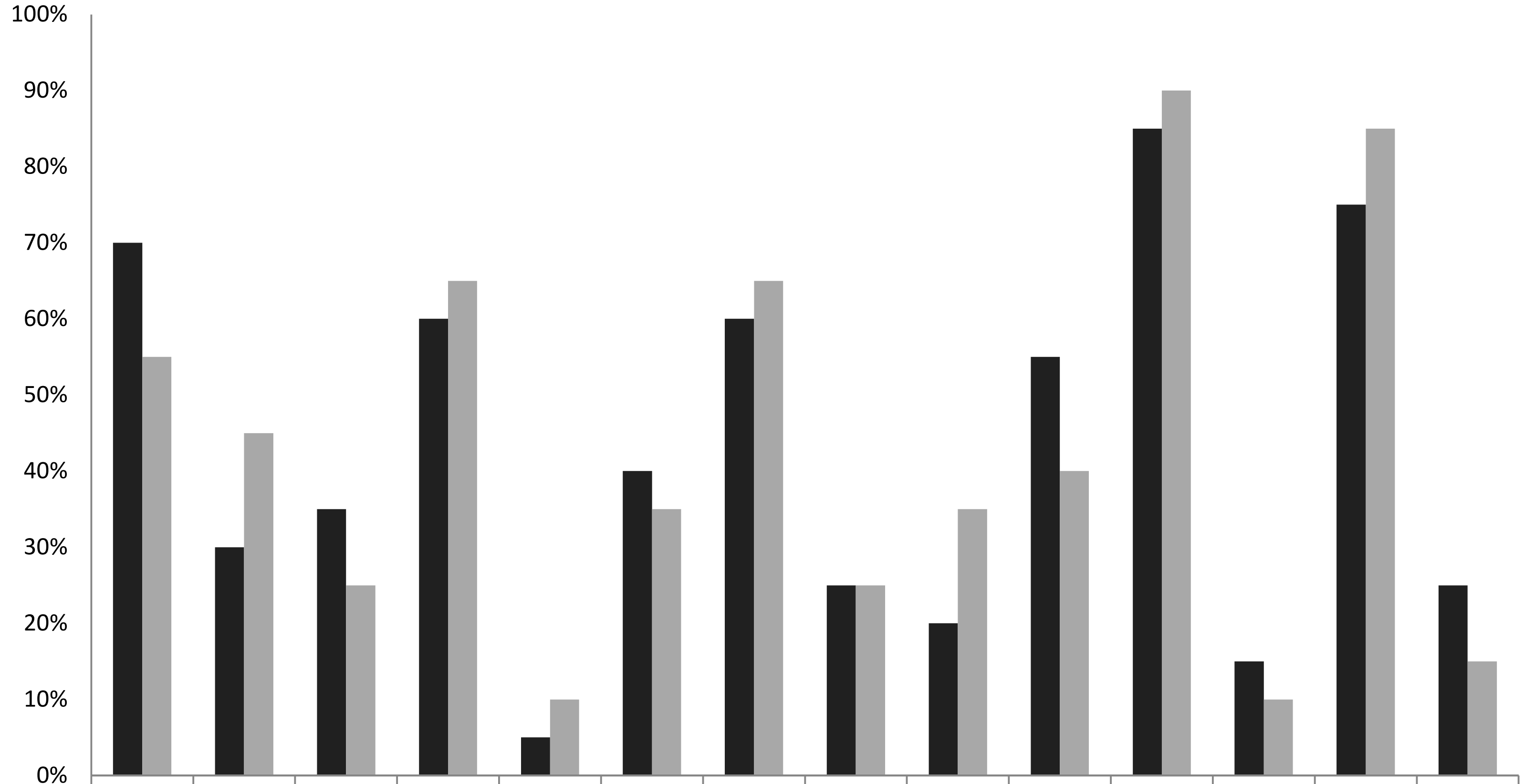
Figure 3.3: The profile of the user sample.

The Table 3.1 illustrate communications items and metaphors that being used in platform for each experimental stage.

3.7 Methodology

Three criteria were chosen to determine the level of usability of both interfaces: effectiveness, efficiency and users satisfaction. Efficiency was measured by the time taken by users to complete each task. Effectiveness was measured by the number of successfully performed tasks. Satisfaction was evaluated by the user's responses to the post-experimental questionnaire. This questionnaire had score options from 1 to 5 using the Likert Scale. Users were required to score ten statements in each interface that covered the experimental conditions. The users were also required to specify their agreement to these statements. The statements concerned the ease of use, ease of learning and usefulness of each metaphor. The data in Figure 3.4 illustrates the user profiles for each group such as personal data, educational background, experience with the use of computers and contacting tutors using electronic means (see Appendix A2).

Forty users, consisting of under-graduate and postgraduate students were selected to investigate the use of multimodal metaphors in an E-feedback interface. Theses sample are collected from faculty of technology at De Montfort University. A post-experimental questionnaire was completed by all users. The users comprised of 37.5% undergraduate students and 62.5% postgraduate students. The users were grouped into



	Gender		Age			Education Level		Using Computer Per Week			Using E-learning Systems		Contact Your Tutor Through Computer	
	Male	Female	18-24	25-39	40-49	Undergraduate	Postgraduate	1-7 Hours	8-14 Hours	15+ Hours	Yes	No	Yes	No
■ Control Group	70%	30%	35%	60%	5%	40%	60%	25%	20%	55%	85%	15%	75%	25%
■ Experimental Group	55%	45%	25%	65%	10%	35%	65%	25%	35%	40%	90%	10%	85%	15%

Figure 3.4: User profile for each interface (control and experimental)

three categories on the basis of their age; 30% were aged between 18-24 years, 62.5% were aged between 25-39 years, and 7.5% were aged between 40-49 years.

3.8 Tasks

There were six tasks that had to be completed by the users. These tasks were divided into different groups. The tasks were based on complexity and type, with the complexity level ranging from easy to complex, through to moderate level and are based on actions that will be done by the user when they interact with the interface. So the relation between complexity level and actions is steady. Moreover, tasks types were derived from feedback classification code. There are seven feedback classification codes: (1) error, (2) correction, (3) comments, (4) explain idea, (5) engage thinking, (6) further suggestions and (7) mark. Each task contained three or four of these codes. The Feedback Classification Code was represented through multimodalities metaphors; for example, errors were represented by text and graphic modals and comments by either recorded speech or avatar. In the visual interface, however, the feedback classification code was represented as text with graphics.

Each task contained questions about each of the feedback classification codes. These questions determined the effectiveness and efficiency. By successfully completing the tasks, the effectiveness of the interface was determined. Efficiency was measured by the time taken by users to successfully complete tasks (see Appendix A1.1 and A1.2).

The tasks depended on the way users received their comments of their feedback; so, there were different tasks in different levels. The tasks progressively became more difficult. The main objective was to establish a viewpoint of the way in which users engaged with the interfaces (multimodal and traditional). The feedback used was a real life example and was provided by an English instructor to an essay written by an international student while the student was studying an English academic course at the University. Both interfaces were tested by users to observe and examine the usability in terms of efficiency, effectiveness and satisfaction.

3.9 Results

This section describes the results in terms of comparisons of efficiency, effectiveness and user satisfaction. It analyses the data and discusses the effects of the special unique design introduced using multimodality to an e-feedback learning interface.

The results were analysed statistically using the nonparametric Kolmogorov-Smirnov test is (K–S test) is a nonparametric test for the equality of continuous, one-dimensional probability distributions that can be used to compare a sample with a reference probability distribution (one-sample K–S test), or to compare two samples (two-sample K–S test) [135 and 136]. K-S test is used to test the normal distribution of the achieved results in terms of answering time, questions correctly answered and the user satisfaction score. Providing that the data was normally distributed, the independent t-test could have been used to evaluate the real difference between the two groups concerning each of these parameters. The parameters used are under the control group (Visual Feedback interface) and experimental group (Multimodal Metaphors Feedback Interface) were the time spent to answer questions of tasks, corrections of answering questions and satisfaction score. This statistical test can be applied when two different experimental conditions are tested independently by two groups of users [138]. Otherwise, Mann-Whitney test is used as a non-parametric equivalent of the independent t-test [135 and 138]. These statistical analyses were conducted at $\alpha = .05$ and important difference was detected if p-value was less than .05 [137 and 139].

3.9.1 Efficiency

3.9.1.1 All tasks

The diagram 3.5 explains the mean value of time spent in each interface group. The time spent can be calculated for both the experimental and control groups. It is noted that the mean time is lower in the experimental group than the control group. The average time for all tasks, as shown in Figure 3.5(a) in the experimental group (see Appendix A3) was 1182.78 seconds but in the control group (see Appendix A4) was 1481.82 seconds. This means that the experimental group with the proposed unique design using multimodal metaphors was more efficient than the control group that used a traditional approach. This is due to the experimental approach taken and the benefits of the multimodal metaphors such as recorded speech, colour, text with graphics, and expressive avatars. The t-test calculations showed that the difference in completion time between the two groups was significant ($t (38) = 3.55$, $cv = 1.686$, $p < 0.05$). Experimental observations showed that users in the control group regularly divided their visual attention between the symbols provided which indicated feedback code and feedback content to understand the presented information and in some cases a visual overload might happened. But the users in the experimental group kept their visual attention to the feedback content as text while they were listening to the natural recorded speech or avatar. This approach obtained a better user concentration on the delivered feedback (see Appendix A3 and A4).

3.9.1.2 Level

Figure 3.5 shows the mean time spent for each task in both interfaces. Generally, the mean time completed in each task of the MMFI group is considerably lower than the average time completed in the VFI. Figure 3.5(b) explains the answering time grouped by the complexity of questions which were designed to increase in difficulty and were equally divided into 2 easy, 2 moderate and 2 difficult. In general, it is observed that the answering time in the experimental group was lower for all complexity levels. It can also be seen that the difference in task completion time between the two groups increased as the level of task complexity increased except moderate and complex level in experimental group. In easy tasks, the mean value of task completion time in MMFI was noted to be 69.6 seconds less than that in VFI.

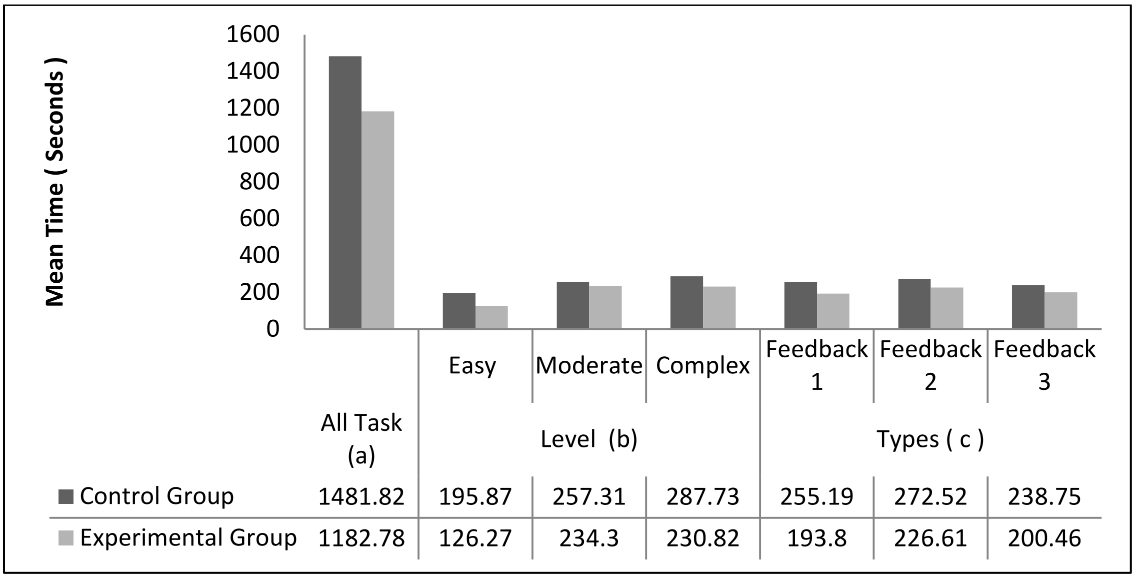


Figure 3.5: Mean values of time taken to answer all questions (a), grouped by task complexity level (b), and by the types of tasks (c) for both interfaces.

The difference between both conditions, however, was slightly larger (23.01 seconds) in response to moderate tasks. With difficult questions, the difference considerably increased to 56.91 seconds in favour of the MMFI.

The statistical tests found that the users of the MMFI needed significantly less time than the users of the VFI to complete each task in the easy category ($t(38) = 6.25$, $cv = 1.686$, $p<0.05$), complex ($t(38) = 3.02$, $cv = 1.686$, $p<0.05$) except Mann-Whitney test of moderate level ($U=157$, $cv=127$, $p>0.05$) questions (Table 3.2). In brief, these results showed that the use of MMFI had gradually contributed in reducing the answering time of the users when the required evaluation questions became more complex.

3.9.1.3 Type

Figure 3.5 explains the relationship between the task types and time taken by users to complete them. As described earlier, task types are divided into Feedback Classification Codes depended on the content of the feedback. Figure 3.5(c) shows the Feedback Classification Code according to the three groups as each group had an emphasis upon a specific modality. The First type is *errors*, *corrections* and *comments* and is referred to as feedback 1, the second type is *explain ideas* and is referred to as Feedback 2 and the third type is *engage thinking*, *further suggestions* and *marks* that is referred to as Feedback 3. The time spent by the MMFI group was lower than VFI group in each type; this can be explained by the MMFI group using more than one channel of communication that in turn reduced information overload and increased engagement with the content. In the VFI group, the use of text with graphics increased information overload which in turn, as observed, lead to the disengagement of users with the information communicated.

Figure 3.5(c) shows the completion time grouped by the question type. Generally, the completion time in the experimental group was lower in all types of questions, as opposed to the control group. Also, users took longer time to answer Feedback 2 questions than Feedback 1 or 3 questions.

However, the difference between the three conditions in answering time was larger in the Feedback 2 questions compared to the remaining types. In responding to the

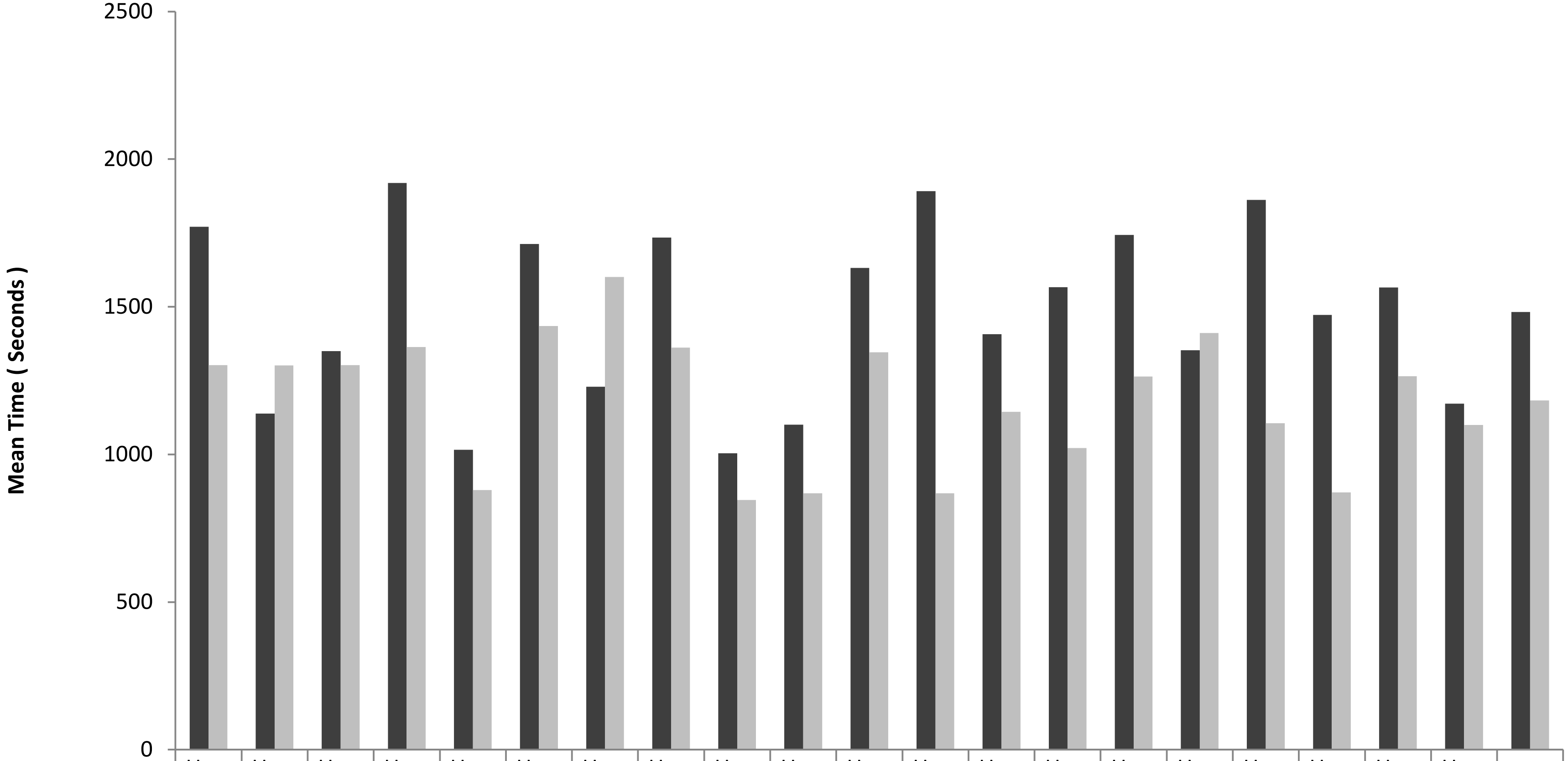
Feedback 2 questions, users of the MMFI in the experimental group spent 45.91 seconds (on average) less than the users of the VFI in the control group. But the difference between the two groups was substantially reduced to 61.39 seconds with respect to answering Feedback 1 questions and 38.29 seconds of Feedback 3 questions. According to t-test results, the difference between the two groups in answering time was statistically significant for Feedback 1 questions ($t(38)=3.56$, $cv=1.686$, $p<0.05$) but no significant difference was reached for the Feedback 2 and Feedback 3 questions respectively ($U=112$, $cv=127$, $p>0.05$) and ($t(38)=2.16$, $cv=1.686$, $p>0.05$) as shown in Table 3.2.

3.9.1.4 Individual User Performance

Figure 3.6 shows the total time spent by each user in each group to answer all questions. A larger time is noted for the users of the VFI compared to the users of the MMFI. The minimum and maximum answering times observed in the control group were 1003.8 seconds (user 9) and 1918.8 seconds (user 4) respectively. In the experimental group, the minimum time observed was slightly lower (846 seconds by user 9) while the maximum time (1600.8 seconds by user 7) was 318 seconds less than that in the control group. On average, the users of the MMFI were 299.04 seconds faster than their counterparts who used the VFI. (see Appendix A3 and A4).

		Statistic value	Significant
Task level	**Easy**	$t(38)= 6.25$, $cv=1.686$, $p<0.05$	Yes
	Moderate	$U=157$, $cv=127$, $p>0.05$	No
	Complex	$t(38)= 3.02$, $cv=1.686$, $p<0.05$	Yes
Task type	**Feedback 1**	$t(38)= 3.56$, $cv=1.686$, $p<0.05$	Yes
	Feedback 2	$U=112$, $cv=127$, $p>0.05$	No
	Feedback 3	$t(38)= 2.16$, $cv=1.686$, $p>0.05$	No

Table 3.2: T-test values and significance level of VFI and MMFI in terms of efficiency.



	User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8	User 9	User 10	User 11	User 12	User 13	User 14	User 15	User 16	User 17	User 18	User 19	User 20	Mean
Control	1771	1138	1350	1919	1016	1713	1229	1734	1004	1100	1631	1891	1407	1567	1743	1352	1862	1472	1565	1172	1482
Experminatl	1302	1301	1303	1364	879	1435	1601	1361	846	868.2	1346	868.8	1144	1021	1264	1411	1105	871.2	1265	1099	1183

Figure 3.6: Mean time taken to answer all questions of each user for control and experimental groups.

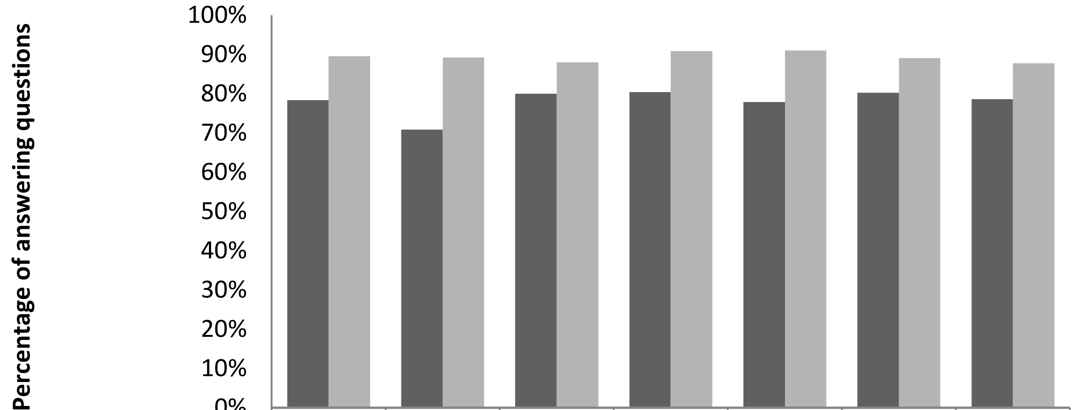
3.9.2 Effectiveness

The percentage of correctly answered questions was used as a measure of effectiveness. This measure was considered for all the questions in total, according to the question type (feedback classification code) and question complexity (easy, moderate and difficult) as well as for each user in both control and experimental groups.

3.9.2.1 All tasks

Figure 3.7 shows the percentage of correctly completed tasks for both interfaces (experimental group and control group). Figure 3.7(a) shows the percentage of correctly completed MMFI tasks to be 90%, but in the VFI it is 78%. This means the performance of users when completing tasks correctly in the MMFI Group is better than the VFI group.

The total number of questions in the control group was 580 (20 user * 29 questions per user) and 560 questions of experimental group (20 user * 28 questioner per user). In Figure 3.7(a), it can be seen that the users of the MMFI performed better than the users of the VFI with regard to the rate of correctness of all their answers. The percentage of correctly answered questions achieved in the MMFI was 90% and 78% for the VFI.



	All Task (a)	Level (b)			Types (c)		
		Easy	Moderate	Complex	Feedback 1	Feedback 2	Feedback 3
Control Group	78%	71%	80%	80%	78%	80%	79%
Experimental Group	90%	89%	88%	91%	91%	89%	88%

Figure 3.7: Percentages of all tasks (a), the level of tasks (b), and the type of tasks (c) completed successfully for the control and experimental groups.

The total number of correct answers in the experimental group was 501, compared to 454 in the control group. The mean value of correct answers per user was 25.05 for the experimental group and 22.7 for the control group. The t-test results showed that the difference in correctly answered questions between MMFI and VFI was significant ($t(38)=4.65$, $cv=1.686$, $p<0.05$) as shown in Table 3.3. The integration of more than one communication metaphor of different nature in the MMFI helped users in the experimental group to highlight the different types of information which has been delivered by each of the metaphors (e.g. recorded speech, text and speaking avatar) and enabled users to assign meaning to the information communicated. So, they outperformed the users of the VFI who received the learning information by visual channel only. Shortly, the multimodal interaction metaphors used in the MMFI was more effective in communicating the learning material and considerably assisted the users in the experimental group to achieve a higher effectiveness rate, as opposed to the control group users.

3.9.2.2 Level

Generally, the percentage of correctly completed tasks in each task of the MMFI group is significantly lower than the percentage of correctly completed tasks in the VFI only. It is observed that there is a difference between the percentage of correct completion in tasks 1, 2, 4 and 6. The relationship between task complexity and percentage of correctly completed tasks is also illustrated in Figure 3.7(b).

Figure 3.7(b) shows the percentage of correctly completed easy, moderate and difficult tasks for both groups. It is noted that the experimental group outperformed the control group in all levels of complexity, particularly in answering the easy questions.

In moderate questions, the users of the MMFI scored 8% more correct answers than those of the VFI. The difference however was larger (11%) with respect to complex tasks and the largest difference (18%) was noted in users completion rate to the easy tasks. Using the MMFI, the users in the experimental group correctly completed 89%, 88% and 91% of easy, moderate and difficult tasks respectively. The users of the VFI in the control group successfully responded to 71% of easy, 80% of moderate, and 80% of difficult tasks.

		Statistic value	Significant
Task level	**Easy**	U=303.5, cv=127, *p<0.05*	Yes
	Moderate	t(38)=1.98, cv=1.686, *p>0.05*	No
	complex	t(38)=2.84, cv=1.686, *p<0.05*	Yes
Task type	**Feedback 1**	t(38)=4.07, cv=1.686, *p<0.05*	Yes
	Feedback 2	t(38)=3.08, cv=1.686, *p<0.05*	Yes
	Feedback 3	t(38)=2.53, cv=1.686, *p>0.05*	No

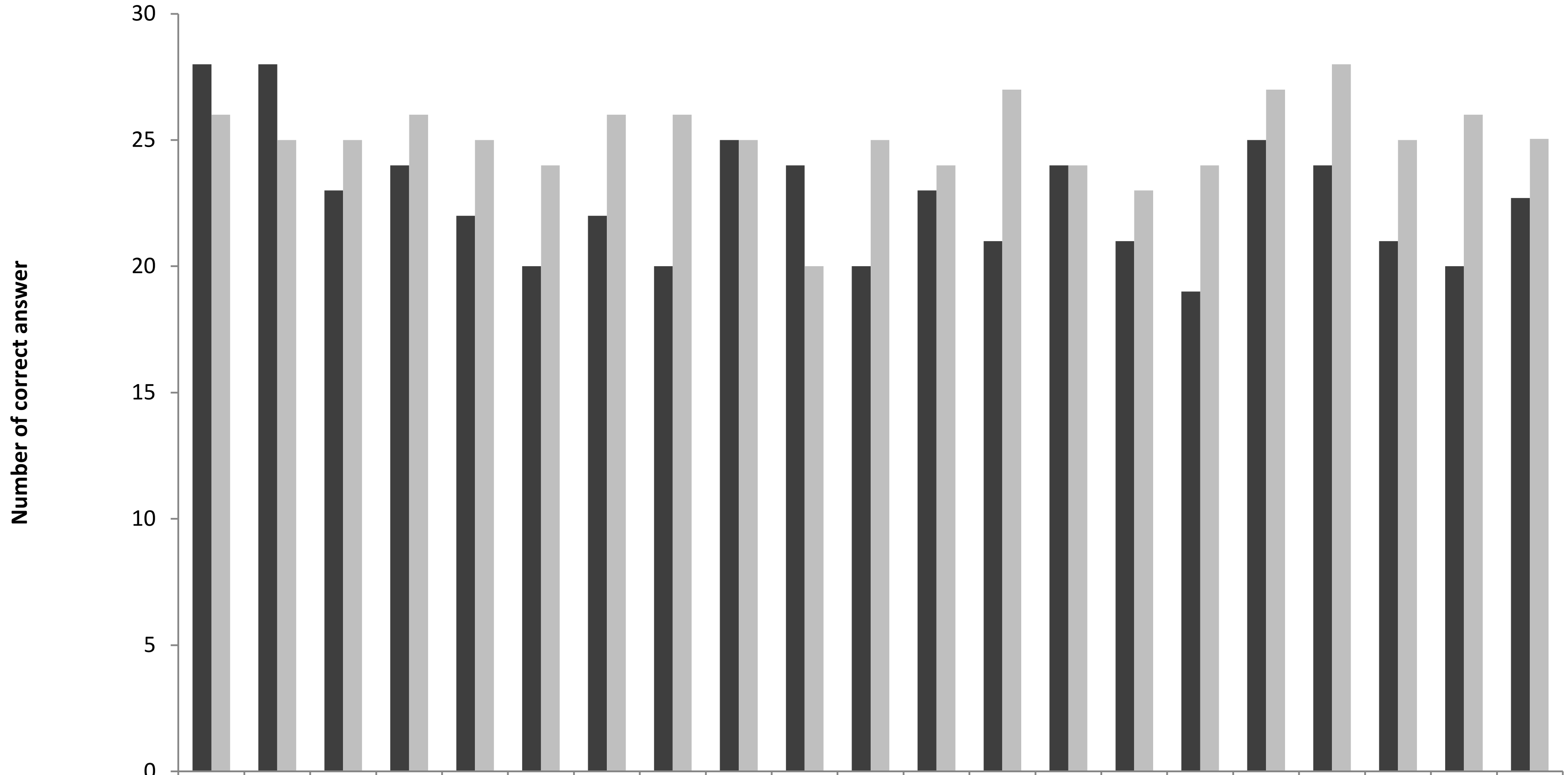
Table 3.3: T-test value and significance level of VFI and MMFI in terms of effectiveness.

The results of t-test showed that the difference in correct answers between MMFI and VFI did not reach a statistical significance in moderate questions (t(38)= 1.98, cv=1.686, p>0.05) while it was found significant in easy (U=303.5, cv=127, p<0.05) and complex tasks (t (38)= 2.84, cv=1.686, p<0.05). In summary, we can say that both groups of users achieved equivalent levels of accuracy of their answers to moderate tasks. However, the contribution of multimodal metaphors in users' performance was clearer to the higher complexity tasks.

3.9.2.3 Type

Figure 3.7(c) shows the percentage of correct answers to feedback code questions in both control and experimental groups. We noted that users of the MMFI performed better than those of the VFI in all feedback codes. With Feedback 1 questions, the percentage of correctly completed tasks in the experimental group was 13% higher than that in the control group. However, the percentage of correctly completed Feedback 2 and Feedback 3 tasks in the experimental group was 9% - higher than that in the control group. Using the MMFI, users in the experimental group gained a correctness rate of 91%, 89% and 88% in Feedback 1, Feedback 2 and Feedback 3 tasks respectively.

On the other hand, the users of the VFI in the control group achieved a success rate of 78% in correctly completing Feedback 1 tasks and 80% in answering Feedback 2 tasks and 79% in completing Feedback 3 tasks. The results of t-test showed a remarkable difference in correct answers between MMFI and VFI conditions for both types of questions; Feedback 1 (t(38)= 4.07,CV=1.686, P<0.05)and Feedback 2 (t(38)=3.08, cv=1.686, p<0.05). However it was not significant in Feedback 3 (t(38)=2.53, cv=1.686, p>0.05) as shown in Table 3.3. In summary, the contribution of multimodal metaphors was more apparent in users' answers to Feedback 1 and Feedback 2 activities compared to that in Feedback 3.



	User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8	User 9	User 10	User 11	User 12	User 13	User 14	User 15	User 16	User 17	User 18	User 19	User 20	Mean
Control	28	28	23	24	22	20	22	20	25	24	20	23	21	24	21	19	25	24	21	20	22.7
Experminatl	26	25	25	26	25	24	26	26	25	20	25	24	27	24	23	24	27	28	25	26	25.05

Figure 3.8: This figure presents the number of correct answer for each user in both interfaces.

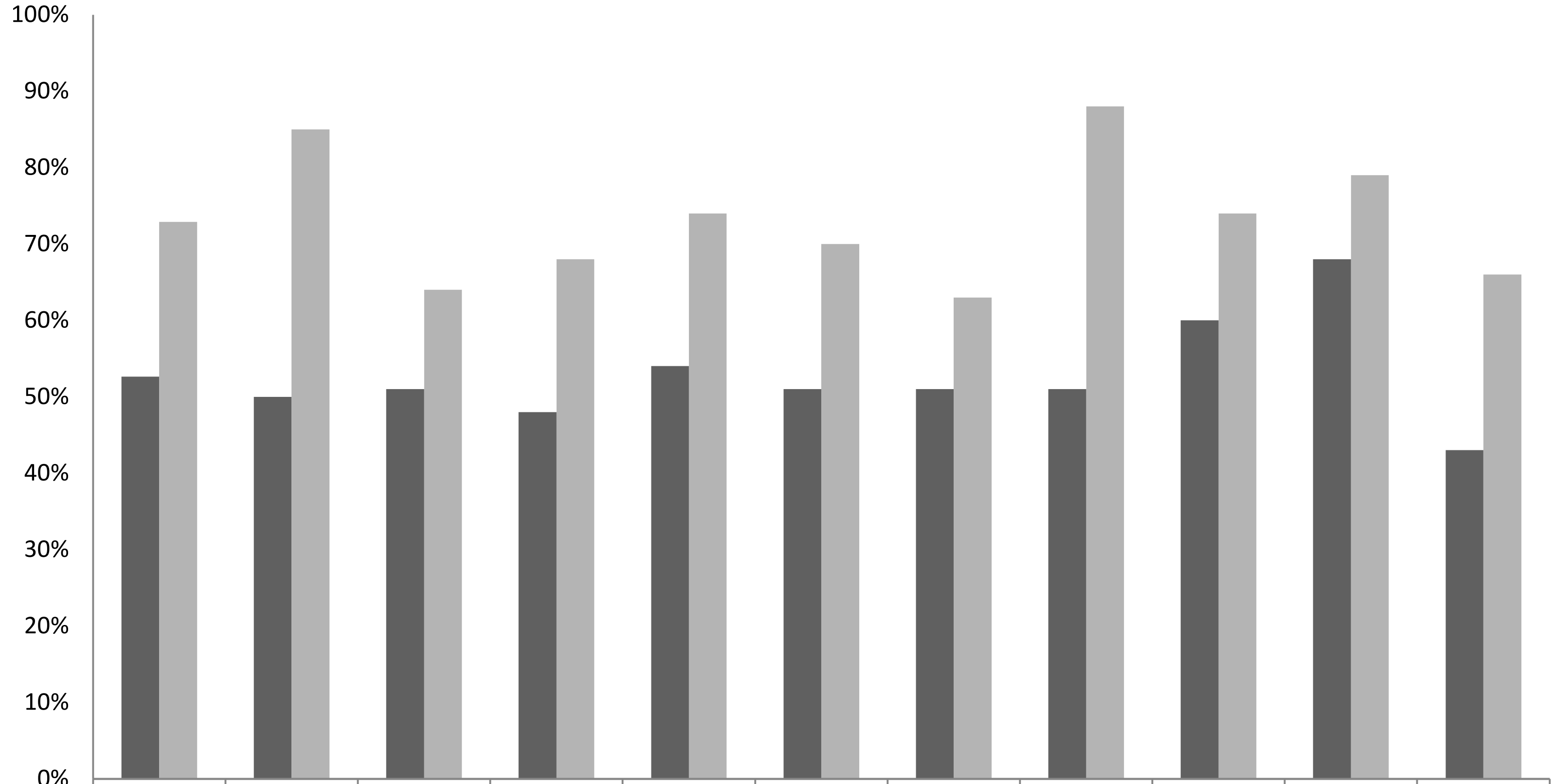
3.9.2.4 Each user

Figure 3.8 shows the total number of correct answers achieved by each user in both control and experimental groups. User 18 of the MMFI correctly answered all the 28 questions and another two users (13 and 17) achieved 27 correct answers. On the other hand, none of the VFI users was able to reach a similar performance level, where the maximum achievement observed was 28 out of 29 correct answers by Users 1and 2. The weakest user in the experimental group (User 10) scored 20 correct answers greater than that in the control group (User 16). On average, the number of correct answers per user in the experimental group was 25.05 compared to 22.7 in the control group. In brief, using multimodal metaphors in communicating the learning material enabled the users in the experimental group to outperform their counterparts in the control group in answering the required questions correctly. (see Appendix A5 and A6).

3.9.3 User satisfaction

Users in both groups also completed a post-experimental questionnaire. This questionnaire had scores from 1 to 5 using the Likert Scale. Ten statements were evaluated for each group [140]. The statements were mainly concerning the *ease of use*, *ease of learning* and *usefulness* of each interface. In Figure 3.9, the mean values of user satisfaction rate is described for both groups. It can be seen that the MMFI user group was more satisfied than the VFI user group. In the MMFI group the mean value of user satisfaction was 73% and in the VFI group was 53%.

User satisfaction with regard to different aspects of the applied e-feedback platform was measured in both groups by users' answers to the post-experimental questionnaire which contains 10 statements 1) *system unnecessarily complex,* 2) *easy to use*, 3) *need the support*, 4) *functions well integrated,* 5) *too much inconsistency*, 6) *use this system very quickly,* 7) *cumbersome to use,* 8) *confident using the system*, 9) *learn a lot of things,* 10) *using the system frequently*. The Five-point Likert scale, ranging from 1 (the value of strong disagreement) to 5 (the value of strong agreement), was used for each statement. The overall satisfaction score for each user was calculated using the SUS (System Usability Scale) method. The mean satisfaction score for the users in the experimental groups was 73% compared to 53% for the users in the control group.



	All Users	S1 Frequently to use	S2 Unnecessarily complex	S3 Easy to use	S4 Need a technical support	S5 Functions well integrated	S6 Too much inconsistency	S7 Use very quickly	S8 Cumbersome to use	S9 Confident using the system	S10 Learn before use the system
Control Group	53%	50%	51%	48%	54%	51%	51%	51%	60%	68%	43%
Experimental Group	73%	85%	64%	68%	74%	70%	63%	88%	74%	79%	66%

Figure 3.9: Percentage of all users each and statement satisfaction of both interfaces.

Statistically, the t-test proved that the difference in users' satisfaction between both groups was significant ($t(38)=4.57$, $cv=1.686$, $p<0.05$). In other words, the MMFI was more satisfactory than the VFI. Figure 3.9 shows the frequency of user agreement with each statement in the satisfaction questionnaire. Quite high levels of agreement were expressed by the users in both groups for their *confidence using the system* (S9). However the MMFI was easier to use (S3) as opposed to the VFI. In the first statement S1, 85% of users in MMFI group agreed that the tested e-feedback interface was less complex compared to 50% in VFI group. The second statement (S2) also similarly asked the users whether they found the system unnecessarily complex. Users of the MMFI expressed a quite high level of disagreement 64% than the users of the VFI 51%.

The level of agreement was observed for S3 where only 68% of the users in MMFI thought easy to use the system with the tested interface but in VFI users thought easy to use was 48%. With respect to S5, the entire MMFI users found that all various functions were well integrated compared to 51% in the VFI. And users' agreement in the experimental group was higher, as opposed to the control group in terms of being able to use the system very quickly and confidently (S7 and S9).

All users found MMFI interface easily understood the communicated information of the feedback compared to 51% using the VFI. In brief, using the multimodal metaphors to convey the learning material resulted in generating positive views of users. Therefore, the MMFI can be considered more satisfactory than the VFI one. (see Appendix A7).

3.9.4 Engagement

Figure 3.10 shows the score for each user in both interfaces. The measurement of users' engagement was achieved by asking the users recall questions about the feedback content to rate their engagement. In general, most users were engaged with feedback in the MMFI because more than one channel had been used in this interface to deliver the feedback. There are fewer users who related with feedback in the VFI platform and their percentages are lower than the MMFI group (see Appendix A3 and A4).

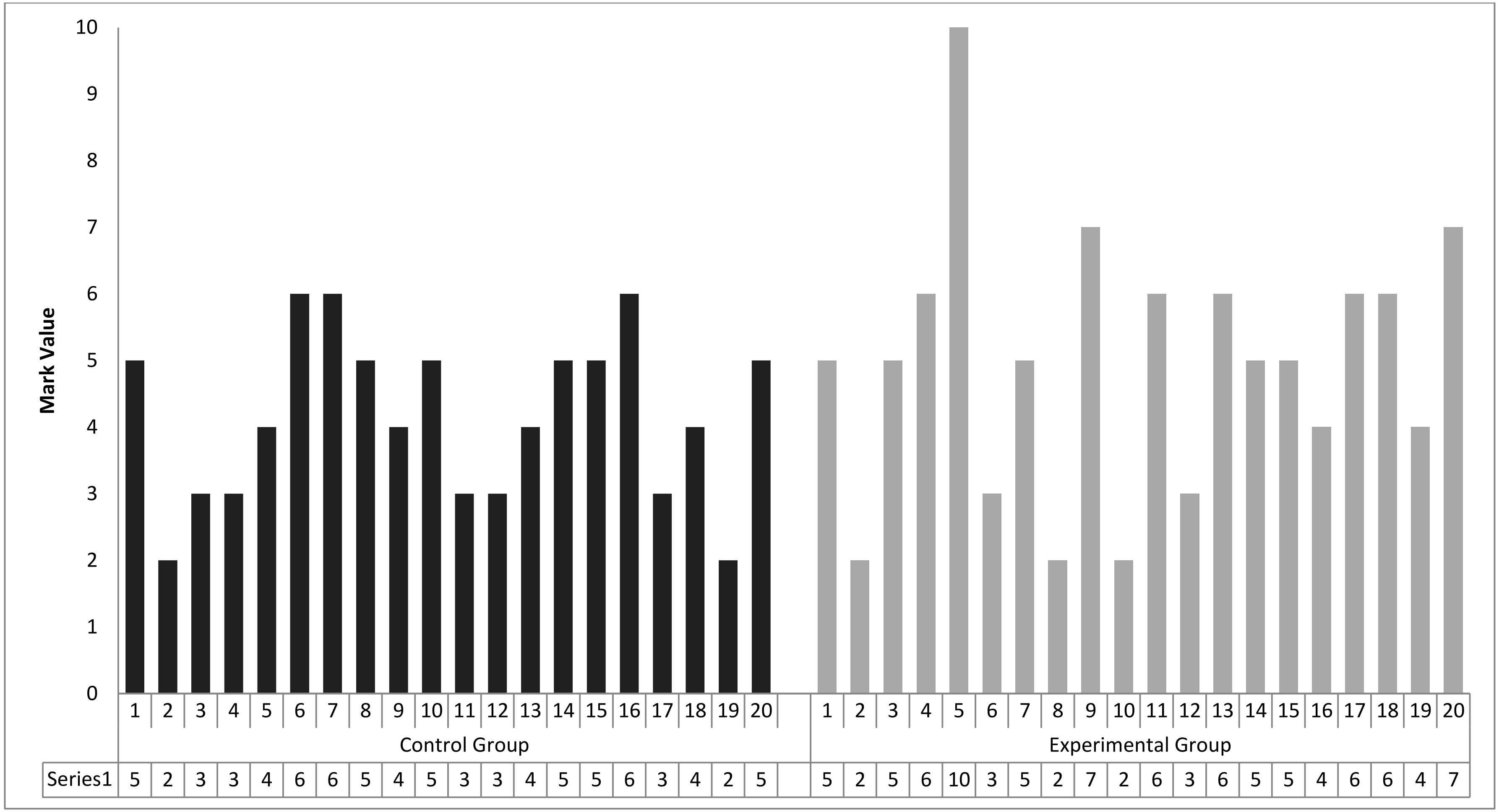


Figure 3.10: These values are marks of student engagement with feedback for both interfaces. It was gained by asking users ten questions after feedback content delivered to them.

3.10 Discussion

This experimental study investigated the usability and learning engagement of MMFI as opposed to VFI text with graphics one. The results have been used to compare the two interfaces in terms of efficiency, effectiveness and user satisfaction. The present study also concentrated on the elements that can affect the role of multimodal interaction metaphors such as the complexity level (easy, moderate and complex) and the type (feedback classification code) of the feedback content. So, these results are discussed from the next three angles to get an insight into what contribution has been made by the multimodal metaphors in users' efficiency, effectiveness and satisfaction. Although the text with graphics interface typically offered simpler interaction, the results showed that the use of multimodal metaphors (natural recorded speech, text, and avatars) was significantly more efficient and effective as well as more satisfactory than using the text with graphics in communicating the learning material in e-feedback interfaces.

3.10.1 Efficiency

The first assumption assumed that the MMFI will be more efficient than using text with graphics, in terms of users correctly understand the communicated content and answer successfully the required questions that verified their knowledge. The experimental results, as shown in Figure 3.5, found that by using the multimodal interaction metaphors there was a significant reduction in the time needed by users in the experimental group to respond to the evaluation questions. Empirical observations found that users of VFI in the control group regularly switched their visual attention between the textual explanations provided in the text box and feedback symbols representations to understand the presented information which may have overloaded their visual channel. On the other hand, users of the MMFI in the experimental group were able to maintain their visual attention to the feedback content while they were listening to the auditory messages delivered by speaking avatar and natural recorded speech. The inclusion of different multimodal communication metaphors in the MMFI helped the users to focus better on the presented information through the auditory channel while at the same time used the visual channel to understand this information [147]. So, they were significantly aided by the addition of these metaphors in the MMFI in terms of spending less time than users of the VFI. In these results it is suggested that by using the speaking facially expressive avatar, text and natural recorded speech could be more efficient than using only the text with graphics metaphors in presenting clarifications related to the learning material used in this experiment, thus accepting what has been assumed.

With respect to task complexity, it was expected, as stated in the assumption, that the MMFI will be more efficient than the VFI with an increasing level of complexity. The results of this experiment (see Figure 3.5(b)) showed an increasing difference in answering time, in favour of the experimental group, as the required tasks progressively became more complex. Therefore, the more difficult the presented learning material, the larger the benefit of using multimodal metaphors. In tasks 1 and 2 (easy level), the presented material was simple and limited users' resources were needed for engagement and processing of the material; Though, with increasing complexity, more information was delivered and less cognitive resources become available for processing [148]. In this case, using multimodal metaphors could benefit in extending the ability of working memory to enable the processing of both verbal (auditory) and non-verbal (visual) information [149]. So, the empirical results showed the gradual contribution of the multimodal metaphors in efficiency as users of the MMFI responded significantly faster to the easy, moderate and complex evaluation questions. These results support the hypothesis. In summary, there is empirical evidence to suggest that the efficiency of the multimodal metaphors is significantly influenced by the complexity level of the content of the communicated feedback.

Considering the question type, the assumption predicted the MMFI will be more efficient for all type of questions. The experimental results showed that the addition of the multimodal metaphors as applied in the MMFI particularly contributed to Feedback 1 questions which means that no significant difference between the two groups was observed for Feedback 2 Feedback 3 tasks. The overall assumption is refused but could be partially accepted for Feedback 1 questions. So the effect of the tested multimodal metaphors on completion time is limited to Feedback 2 and 3 activities regardless of its difficulty.

3.10.2 Effectiveness

It was expected that users of the MMFI would outperform VFI users in terms of correctly completed tasks. As shown in Figure 3.7, the MMFI was superior to the VFI in enhancing users' learning achievements. Using more than one communication metaphor of a different nature in the MMFI attracted the users and captured their attention. It also assisted users to differentiate among the different types of information provided by each of these metaphors and enabled them to remember this information for longer time. This is because of the multimedia principles [150]; involving other senses than the visual channel in the interaction process could assist in extending the capacity of working memory and the users' ability to perceive and understand the presented information could be enhanced. The fact that users in the experimental group retained the communicated information for longer time (compared to the control group) enabled them to attain significantly a higher number of correct answers than their counterparts in the control group.

In terms of task complexity, it was assumed that the MMFI will be more effective than the VFI with an increasing difficulty of the required tasks. In this regard, the obtained results (see Figure 3.7(b)) were similar to those observed for efficiency. Although the MMFI condition outperformed the VFI condition in completing moderate tasks, the influence of the multimodal metaphors did not reach a significant level. As mentioned before, these questions were simple and the users in both conditions were able to easily get the correct answer. However, a larger contribution of the multimodal metaphors was observed when a higher level of mental processing was needed where users in the experimental group achieved significantly higher correct answers than the control group in easy and difficult tasks. These results affirm the effect of multimodal metaphors with increased complexity tasks and demonstrate that users' engagement can be improved by the incorporation of these metaphors in e-feedback interfaces. In other words, the complexity level of the presented learning content can influence the effectiveness and the efficiency of the tested multimodality in e-feedback interfaces.

The empirical results, as expected in the hypotheses section, showed that users of the MMFI achieved substantially more correct answers than the VFI users in questions

Feedback 1 and 2. In order to successfully answer all questions type, users had to correctly use their senses to get feedback content. Information in the MMFI was presented in a teacher like scenario in which the avatar simulated a teacher with natural head movement, facial expressions and natural speech while other aspects of the learning materials were presented using text and graphics. The results of this experiment found that user learning experience as formed by the combined multimodal metaphors enabled users to engage better without distracting their attention away from the presented content.

3.10.3 User Satisfaction

In general, it was expected that users of the MMFI would be more satisfied than the users of the VFI. Consistent with this assumption, the multimodal presentation of the feedback material in the MMFI has shown to be significantly more satisfactory than the text with graphics in the VFI. It seems that using the facially expressive avatar in a human-like approach in addition to natural recorded speech and text was interesting and attractive for users in the experimental group. So, they expressed a more positive situation towards the audio-visual communication of the learning material. Although both of the tested e-feedback interfaces were different and users were confident in using the system, the obtained results did not demonstrate a remarkable difference between both groups of users regarding these satisfaction features (refer to S6 to S9 in Figure 3.9). A larger difference however was observed on specific statements related to using system *frequently* and *quickly* (refer to S1 to S7 in Figure 3.9). These results derived from two independent groups and users within those two groups were not presented with both interface versions in order to make an informed comparison.

Typically, users in the experimental group thought that their learning was better aided by the multimodal metaphors. It was easier for them to identify comments and engage thinking and further suggestions about their feedback, which have been communicated by avatar, natural recorded speech, and text. This result on its own is not conclusive; as it is based on a subjective rating of users and the typical mean value difference is not large enough (although a statistical significance for the overall satisfaction results was reached). However, when user satisfaction, efficiency and effectiveness results are combined with each other, the argument that users in the experimental group were helped by the multimodal metaphors becomes much stronger. It can therefore be extrapolated that the multimodal aided e-feedback interface is more likely to result in an enjoyable and satisfying experience for the user.

This experience is related with the ability to complete learning tasks correctly and quickly. In brief, the whole results of this experimental study suggests the importance of the design approach taken using multimodal interaction metaphors to enhance user engagement and the usability of e-feedback interfaces in terms of efficiency, effectiveness and user satisfaction.

The experimental e-feedback interface will be improved further in order to test the main hypothesis of this research program as well as for answering the research question and finally to achieve the main goal of this research program; deriving guidelines in the use of multimodality in the design and implementation of e-feedback interfaces. Additional multimodality like avatar with body gestures could be used. Also, synthesis speech, more facial expression could be included to present feedback content in the interface of such systems. A large number of comparative usability experiments will be performed to test and evaluate the use of multimodal features included in the interface of the experimental tool, to investigate the contributing role of each metaphor and to explore which would give better results. More subjects are expected to be involved in these experiments and more usability metrics could be considered. The results of these experiments will be analysed using suitable statistical techniques.

3.11 Conclusion

This Chapter presented an empirical investigation on usability issues of e-feedback. Usability was investigated in terms of efficiency (time taken to complete tasks), effectiveness (tasks completed correctly) and satisfaction. The results showed that the use of multimodal metaphors with expressive avatars to communicate feedback (on an essay type of learning material) increased the user understanding and reasoning of the content of the feedback provided. It also enabled users to understand and reason faster because of the type of feedback received. The multimodal approach also increased user engagement and satisfaction as users received more information simultaneously by utilising several modalities. Also, using a facial expressive avatar with natural recoded speech enabled the user to feel part of a face-to-face teaching environment and receive feedback in a tutorial style. The more complex the feedback provided, the greater the benefit received by the multimodal approach. However, larger scale experiments with different types of e-feedback material are needed to investigate these issues further. Chapter 4 will focus on investigating each feedback type on its own and compare them using with different interfaces. Further investigation with facial expression avatars and "video" are needed to investigate further and deeper interfaces for e-feedback using the usability in terms of efficiency, effectiveness and how student engagement will be.

Finally this chapter presented an empirical investigation on usability issues of e-feedback. Usability was investigated in terms of efficiency (time taken to complete tasks), effectiveness (tasks completed correctly) and satisfaction. Efficiency was measured by the time spent on completing each task in both interfaces; effectiveness was measured by examining the percentage of tasks completed correctly in the multimodal metaphors interface and the visual interface. Satisfaction was measured by obtaining the responses of users to user satisfaction questions at the end of experiment. The experimental stage of the study is based on two different interfaces. The first interface was the control group with a visual feedback stimuli. The second interface was the experimental group with the multimodal metaphors to communicate feedback (visual, audio and avatar).

The results indicated that the multimodal metaphors reduced the time needed by users to respond to the required tasks and facilitated users to perform these activities more accurately as well as making the interface more satisfactory. In other words, it can be concluded that the tested multimodal metaphors significantly contributed in enhancing user's engagement with feedback and the usability of e-feedback interfaces in terms of efficiency, effectiveness and user satisfaction. Therefore, the inclusion of multimodal metaphors should be taken into consideration when designing user interfaces of e-feedback.

More specifically, the results showed that that the use of multimodal metaphors with expressive avatars to communicate feedback (on an essay type of learning material) increased the user understanding and reasoning of the content of the feedback provided and it also gradually contributed in reducing the answering time of the users when the required evaluation questions became more complex. Also, although the text with graphics interface typically offered simpler interaction, the results showed that the use of multimodal metaphors (natural recorded speech, text, and avatars) was significantly more efficient and effective as well as more satisfactory than using the text with graphics in communicating the learning material in e-feedback interfaces. However, the contribution of multimodal metaphors in users' performance was clear in their responses to the higher complexity questions.

Chapter 4

Multimodal metaphors to Communicate e-feedback: A Three Platform Approach

4.1 Introduction

Experimental results obtained from the first experiment demonstrated the importance of recorded speech and speaking facially expressive avatars in enhancing usability and user's engagement in e-feedback interfaces. These results however did not clearly identify the contributing role of each of these multimodal metaphors in the obtained enhancement. This Chapter describes the second experiment that has been conducted to explore and compare the role of avatars when incorporated as virtual lecturers in e-feedback interfaces to present six different feedback types. In addition to textual and graphical communication metaphors, synthesised speech and animated speaking avatars were employed in three different modes of presentation which are speaking video with facial expressions in a face-to-face platform, synthesised speech with the text platform and speaking avatars with facial expressions and body gestures platform. The following sections provide a detailed description of the research aims, objectives, hypotheses, experimental platforms, design of the experiment, results and discussion.

4.2 Objectives

The objectives of this study is to investigate the effect of multimodal metaphors (synthesized speech, natural facial expressive, natural recorded speech and facial expressive avatar with body gestures) and feedback type in an e-feedback interface on usability. Moreover it is aimed to obtain user's perspective about the interface which is delivering different feedback type more effective in terms of using face to face, synthesised speech and avatar with body gestures. Also, it is testing usability in terms of efficiency, effectiveness and satisfaction through using different following platforms:

1. Face to face platform feedback.
2. Synthesised speech platform feedback.
3. Avatar with body gestures platform feedback.

4.3 Tasks

1. Formulate experimental hypotheses.
2. Development of three experimental platforms that communicate a typical (University level) feedback using three different presentation modes, face to face (video) with text, synthesised speech with text and finally speaking avatar with facial expressions and body gestures with text.
3. Experimental evaluation of the three platforms (face to face, synthesized speech and avatar body gestures) using a dependent study to examine and evaluate each interface. This comparative study will aid the evaluation of usability.
4. Measure efficiency in terms of time taken by users to complete each task in all platforms.
5. Measure effectiveness (corrected task and student's engagement). Each task has several questions and these questions need to be answered by users after each task is performed. Therefore, the effectiveness is measured by assessing the correct answers to these questions.
6. Measure user satisfaction by allowing users to rate the three experimental platforms against a set of criteria.
7. Analysis of the results in a comparative study in order to determine the suitability of each of the metaphors used in the context of e-feedback.

4.4 Hypothesis

The introduction of this new approach to communicate different types of e-feedback in the context of e-learning interfaces will have an effect upon the usability of these interfaces. Adding positive facial expressions of the avatar and face to face will influence the usability and user's engagement. Therefore, the hypotheses proposed are:

H1 Positive facial expressions as part of a facially expressive avatar that communicates e-feedback will be rated positively by users in terms of being meaningful and understood for all feedback types.

H2 Positive body gestures as part of a facially expressive avatar with body gestures that communicates e-feedback will be rated positively by users in terms of being meaningful and understood for all feedback types.

H3 Voice expression using synthesised speech as a means to communicate e-feedback will be rated negatively by users in terms of being meaningful and understood for feedback types.

H4 When e-feedback is communicated using different multimodal metaphors (e.g. face to face, avatar body gestures or synthesised speech) for the different types of feedback, variable efficiency (i.e. time taken by users to complete tasks), effectiveness (i.e. successfully completed tasks) and user satisfaction rates will be observed.

H5 There will be good fit between multimodal metaphors used and feedback types in term of usability parameters of efficiency, effectiveness and satisfaction.

4.5 Experimental Platform

Three different e-feedback platforms that implemented the designs proposed in this Chapter were designed and implemented. These platforms served as a basis for the investigation. The presentation methods implemented in these platforms were: (1) speaking video with facial expressions in the face-to-face platform, (2) synthesised speech in the text platform and (3) speaking and expressive avatars in the facial expressions and body gestures platform.

4.5.1 Feedback Types

Six different types of feedback were communicated to users by the experimental interfaces. The first type of feedback was about the *location of error* that the tutor identified within the assessed work. The second type was about the *tutor's expressed comments* that may demonstrate techniques or procedures that the student has not followed or used appropriately. The third type was about *student's engaged thinking* that enables the user to reason and reflect upon the merits or shortfalls of their written or presented work. The fourth feedback type was about *explaining ideas or concepts* that is primarily used to clarify issues to students. The fifth type was about *further suggestions* that refer users to further study or reading. The final type was the *mark* with the justification for the assigned marks or grades.

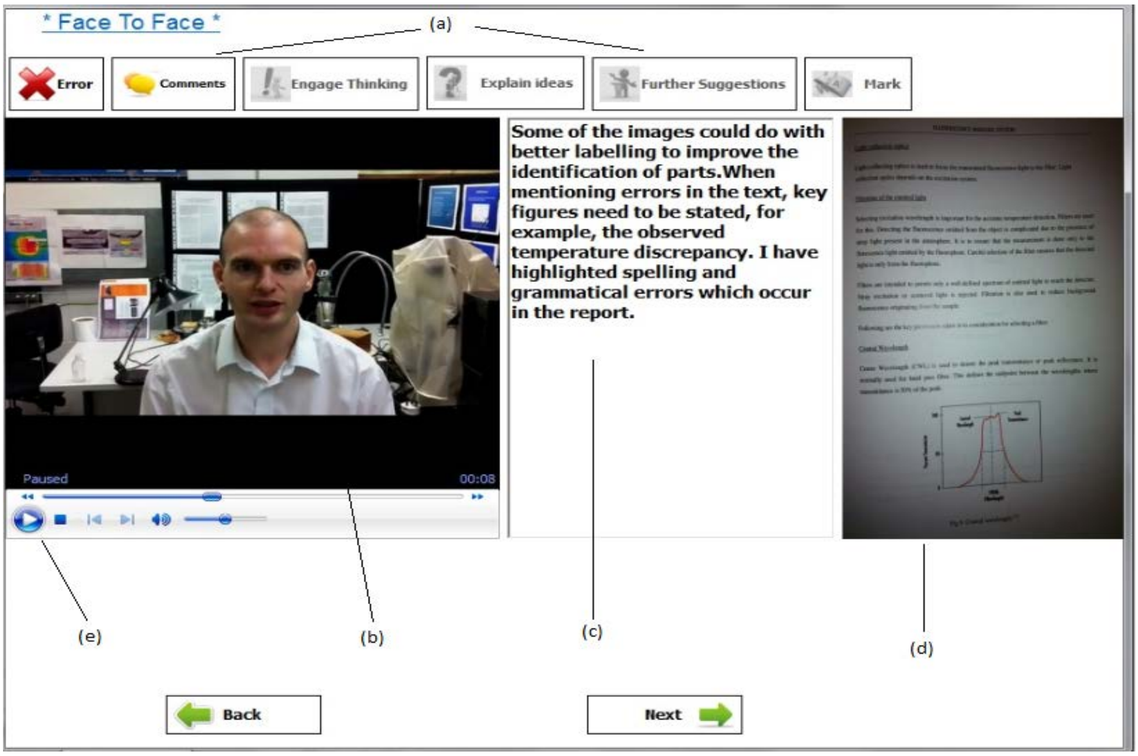


Figure 4.1: Screenshot of Face to Face (video) platform.

4.5.2 Face-to-face Feedback using Video with Text

This platform, see Figure 4.1, uses video with facial expressions and text. The interface provides command buttons (denoted by (a) in Figure 4.1) to enable the selection of the feedback type to be presented. It also provided two separate components for the presentation process namely face to face (video) (b) on the left-hand side of the interface and text of feedback type selected (c) on the middle of the interface. On the right-hand side of the interface, a typical coursework/assignment of a student is presented (d). When the user clicks the button of a given feedback type, this button is highlighted to indicate the current feedback type (other presentations are hidden) and the face to face lecturer starts presenting the feedback type supported by text that is displayed in the text box. The interface also offers pause/play functionalities (e) to enable users to control the pace of watching/listening at any point of time.

4.5.3 Synthesised Speech with Text

This platform, see Figure 4.2, uses synthesised speech with text. The interface provides command buttons (denoted by (a) in Figure 4.2) to enable the selection of the feedback type to be presented. It also provides two separate components for the presentation process namely synthesised speech (b) on the left-hand side of the interface and the text

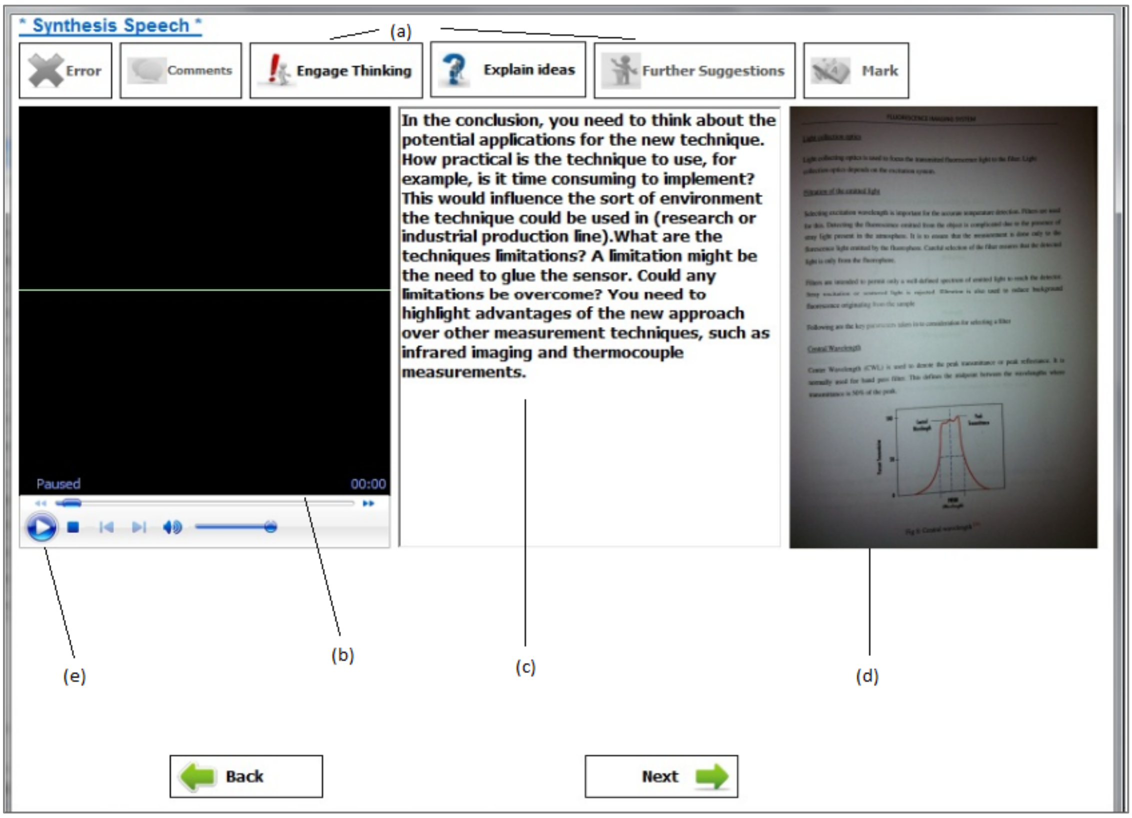


Figure 4.2: Screenshot of synthesised speech platform.

of the feedback type is selected (c) on middle of the interface. On the right-hand side of the interface a typical coursework/assignment is presented (d). When the user clicks the button of a given feedback type, this button is highlighted to indicate the current feedback (the remaining are hidden) and the synthesised speech presents the feedback type supported by text displayed in the text box. The interface also offers pause/play functionalities (e) to enable users to control the pace of their watching/ listening at any point in time.

4.5.4 Facially Expressive Avatar, Body Gesture, Text and Speech

This platform employed speaking and expressive avatars with half body gestures. Figure 4.3 shows the text (denoted (c)) and the virtual interface. This approach could be considered as the closest to a real feedback situation as the virtual lecturer was designed to simulate the same body movements usually performed by a typical lecturer in a traditional feedback session. Similarly to the face to face (video), interface features for feedback type selection (a), pause/play (e) and current feedback highlighting (a) were provided by this interface using avatar body gestures using a half body animated virtual lecturer (b) as shown in Figure 4.3.

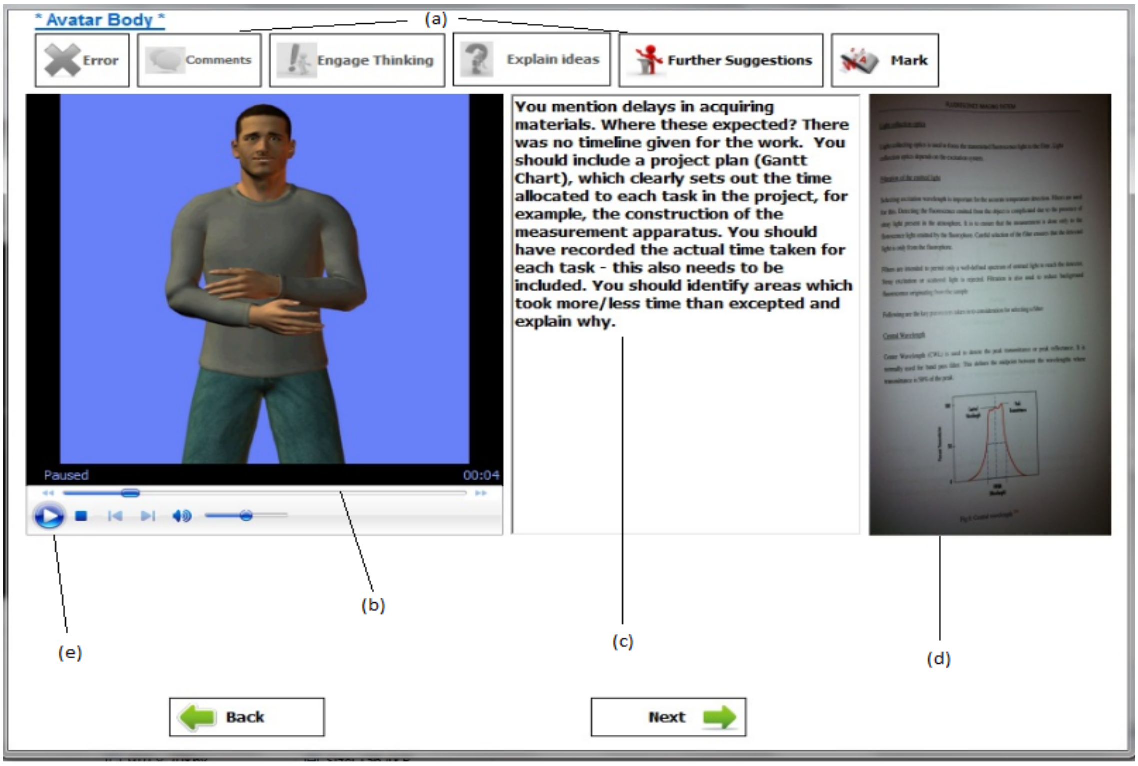


Figure 4.3: Screenshot of the expressive avatar with body gestures platform.

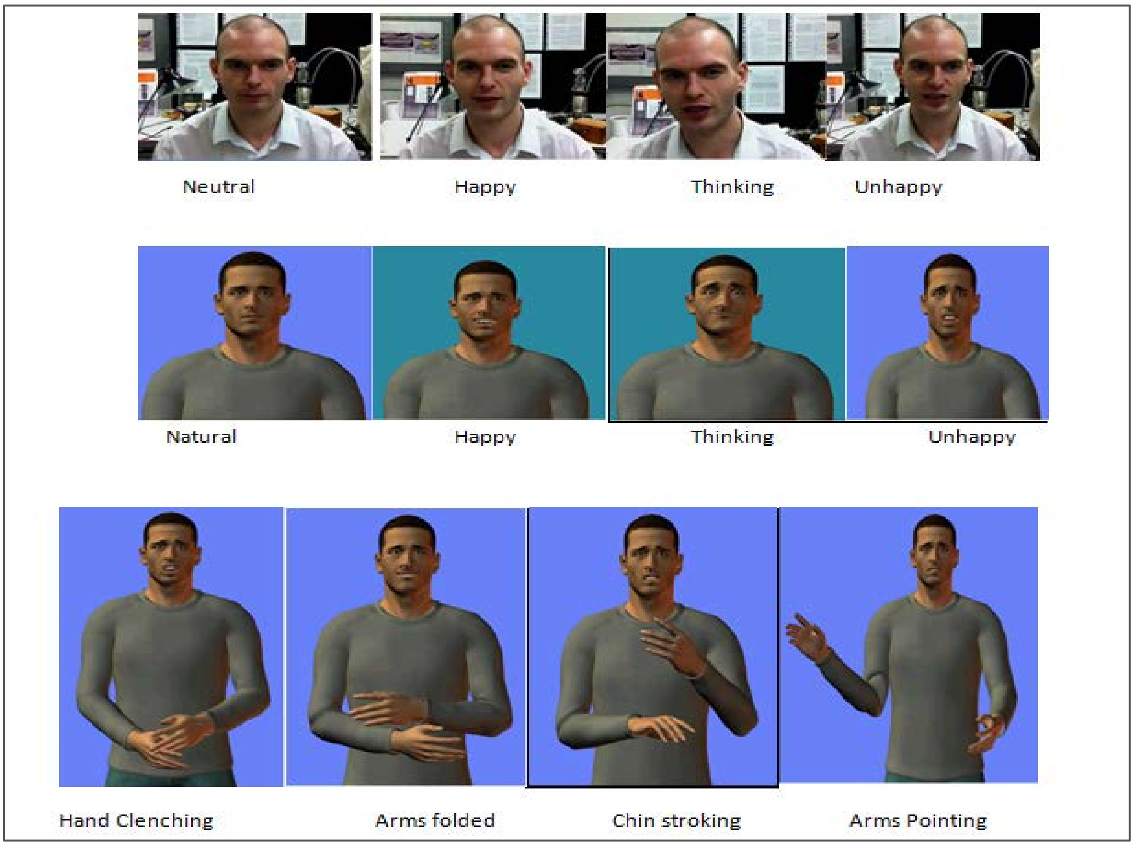


Figure 4.4: Facial expressions and body gestures used in the experiment.

4.5.5 Implementation

Figure 4.4 shows examples of facial expressions and body gestures used in the experiment [141]. Four facial expressions were commonly used in both face to face platform and avatar body gestures, [146] whereas four body gestures were used in avatar body gestures platform. These typical expressions and gestures are often used by teachers or instructors when feedback is communicated to students [146]. Facial expressions and body gestures are classified into three groups; *positive, neutral* and *negative* [145 and 143]. The software eSpeack was used to present the synthesised speech [144 and 142].

4.6 Experimental Design

The within-subjects design approach was followed in carrying out this experimental research. This design allows the participation of each user in testing all the systems being assessed; therefore, it brings down the effect of any other external features that might impact user performance from one treatment to another [138]. Therefore, one group of users was involved to evaluate the experimental e-feedback platforms: face to face, synthesised speech, and avatar body gestures platforms. A total of 36 users have taken part in the experiment on an individual basis. This experiment was composed of four main parts. The first part was the pre-experimental questions for users' profiling and to obtain their viewpoints with regard to previous knowledge about feedback and its types. The second part introduced the experimental platforms by showing a 2-minute video recording to explain how to do the experiment. In the third part of the experiment, the experimental platforms were demonstrated to users and users were presented with the experimental feedback types interactively (see also section 4.5.1). The last part obtained an overall feedback from users related to the usefulness of the implemented multimodal metaphors, their preferred experimental platform, and their comments or suggestions. Refer to appendix B to see the experimental data.

4.6.1 Instruments

A total of 36 users have taken part in the experiment individually and three feedback groups with six feedback types were communicated using the experimental platforms. The procedure followed in performing the experiment with each user is shown in Table 4.1 and detailed in the following sections (see also Appendix B1).

Users	Pre-experimental Questionnaire	Demonstration of the experiment	Feedback 1	Post-conditional tasks	Feedback 2	Post-conditional tasks	Feedback 3	Post-conditional tasks	Post-experimental tasks
1,7,13,19,25,31			FTFP		SSP		ABGP		
2,8,14,20,26,32			FTFP		ABGP		SSP		
3,9,15,21,27,33			SSP		FTFP		ABGP		
4,10,16,22,28,34			SSP		ABGP		FTFP		
5,11,17,23,29,35			ABGP		FTFP		SSP		
6,12,18,24,30,36			ABGP		SSP		FTFP		

Table 4.1: Procedure followed in conducting the second experiment (acronyms defined in page 15).

4.6.1.1 Pre-Experimental Questionnaire

It was important to collect information of the user sample in order to ensure that it matched criteria for the experiment. The pre-experimental questionnaire obtained the following user information:

1. Educational background.
2. Knowledge about feedback and its types.

4.6.1.2 Demonstration of the Platforms

The experimental platforms were introduced by showing a 2-minute video recording that described the components of the interface of each platform. Thereafter, six feedback using a typical coursework were presented interactively using the experimental platforms. These feedbacks were relating to the specific coursework. Therefore, the order of presentation was the same for all users (i.e. feedback 1, feedback 2, and feedback 3). However, each platform was used once with each user presenting one of these feedbacks. In order to ensure that all experimental platforms had been equally used for each feedback, these platforms were assigned to the six feedback on a systematic rotation basis as shown in Table 4.1.

4.6.1.3 Post-Conditional tasks

These tasks were required to be performed upon completion of feedback type and were aimed at evaluating the users' perceptions of the platform used. It was also aimed at comparing the usability in terms of efficiency, effectiveness, and user satisfaction. Each user was asked to answer four questions related to the delivered feedback type.

Furthermore, the user had to respond to the user satisfaction questionnaire. More specifically, this questionnaire was composed of 18 statements each of which had a 5-point Likert scale where one denoted strongly disagree and five denoted strongly agree. The first 10 statements were based on the SUS questionnaire to measure users' attitude towards different aspects of the applied platform. However, the remaining statements were added to obtain users' feedback about their learning experience with each experimental platform.

4.6.1.4 Post-Experimental questionnaire

Users' views were collected about the perceived usefulness of the multimodal metaphors used in the experimental platforms. Each user was required to rate each metaphor on the usefulness scale ranging from one (representing least useful) to five (representing most useful). Also, users were asked to select one experimental platform which they most preferred and finally to provide their suggestions or comments (if any).

4.6.2 Independent Variables

1. *Multimodal metaphors.* This variable has three conditions that relate to the presentation mode of feedback delivery. These conditions are face to face (video), synthesised speech and expressive avatar with body gestures.
2. *Feedback type.* As described in section 4.5.1, there are six different types of feedback. These feedback types (error, comments, engage thinking, explain ideas, further suggestions and mark) are used as independent variables. By asking these kind of questions we will know how the user recall feedback content which delivered and the effect of that on usability term of efficiency and effectiveness.
3. Recall and Recognition question. In each platform, questions type will be tested. In recognition questions, the user will examine to recognise between different types of feedback.

4.6.3 Dependent variables

The usability parameters are:

1. Efficiency (time): This is the time taken by users to complete a task.
2. Effectiveness (correctness): It is the number of successfully performed tasks.
3. User satisfaction: it is obtained by the user's responses to the post-experimental questionnaire.

User views regarding face to face with text: assessed by the percentage of positive and negative users' views in regard to each of these expressions. Also, user view regarding audio (synthesised speech) with text: assessed by the percentage of positive and negative users' views in regard to each of voice expression. Moreover, user views regarding avatar with body gesture and text: assessed by the percentage of positive and negative users' views in regard to each of facial expressions used and body gestures. Finally, preferred E-feedback interfaces, reached by calculating the percentage of users who chosen each of the tested platforms.

4.7 Data Collection

The collection of experimental data was mainly based on observations and questionnaires. For example, users' answers to both pre and post experimental questionnaires helped to gather data needed to obtain an overall feedback about the characteristics of the users and their opinions relating to the use of the multimodal e-feedback platforms. Furthermore, users' responses to the post-conditional tasks contributed to the evaluation of preferred multimodal metaphors used.

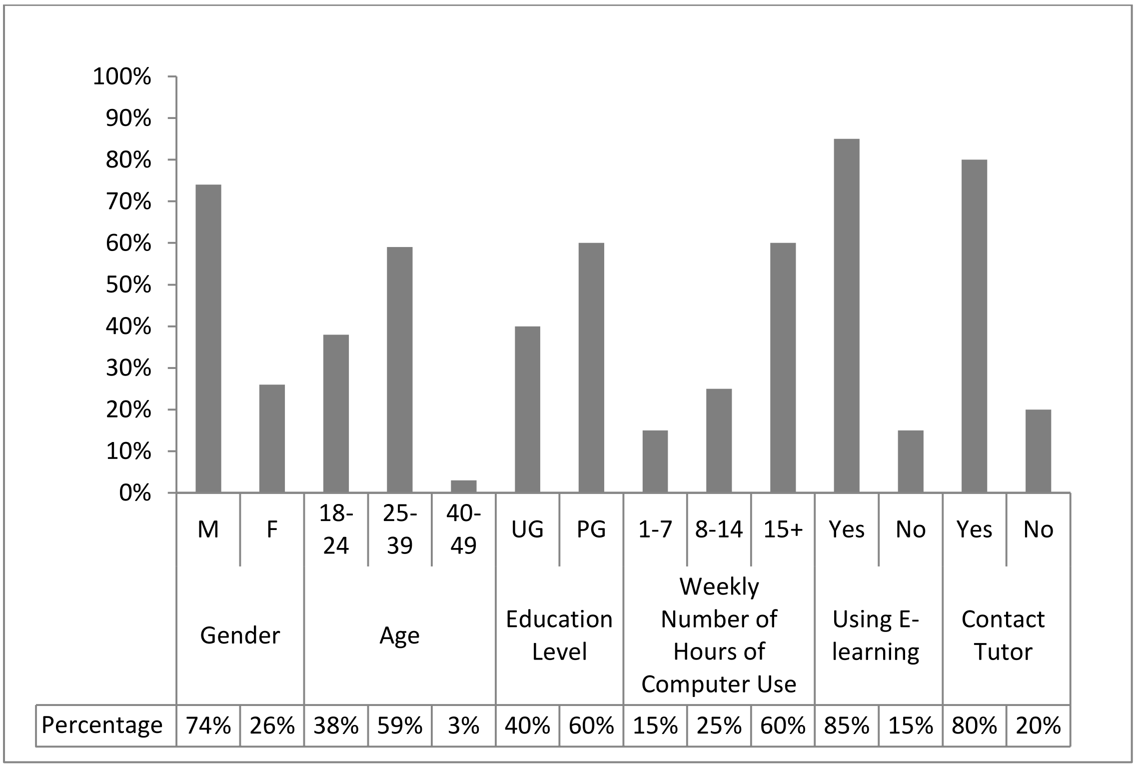


Figure 4.5: The profile of the sample.

4.8 User's Profile

Figure 4.5 shows the profile of the sample. The data includes the level of education, experience with the use computers, e-learning systems or online communication with tutors (see appendix B2).

Forty users, consisting of under-graduate (40%) and postgraduate students (60%) were recruited to investigate the use of multimodal metaphors in an E-feedback interface.

A post-experimental questionnaire was completed by all users. The age profile of the sample was 38% were between 18-24, 59% were between 25-39, and 3% were between 40-49 years old. The user sample was 74% males and 26% females. Figure 4.5 shows that the number of participants who had contacted their tutor through a computer regarding feedback in the experiment was 29 while 20% of participants did not contact their tutor through a computer. In order for the experiment to be successful, all participants had to satisfy a certain criteria: (a) participants had to be computer literate (i.e. used computers for more than 10 hours a week); and (b) participants had not used the experimental platform before. The analysis of the respondents found that 60% had used a computer for more than 15 hours; 25% had used a computer for between 8-14 hours was; and 15% had used a computer for 1-7 hours per week. The proportion of participants who used E-learning systems was 85%.

Figure 4.6 shows the user's experience in E-feedback interfaces. Approximately 93% of the users read the feedback that written or sent by their tutor while 7% do not read the feedback which means they ignore it. 88% of users faced difficulty when they want to read the feedback for overloading or incomprehensible purposes. Approximately, 70% of users believed that the addition of facially expressive avatars could help with the delivery of e-feedback. In contrast 77% of users thought that the addition of synthesised speech would not help with the delivery of e-feedback. On the whole, importance rating for adding avatar body gestures with facial expression could help to deliver feedback through e-feedback interface.

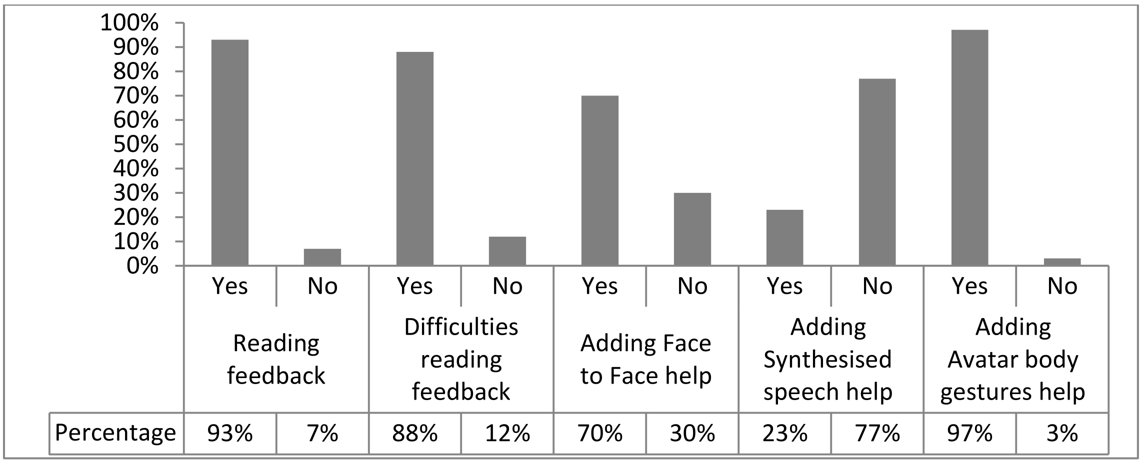


Figure 4.6: User experience in E-feedback interface.

4.9 Results

For the statistical analysis, the nonparametric Chi-square test was used to examine the significance of the differences in terms of categorical data such as users' views [136, 138]. The Kolmogorov-Smirnov test showed that the remaining data was not normally distributed and therefore Friedman's ANOVA was used. This test can be used to test the differences between experimental conditions in within-subjects design when the assumption of normal distribution of the data is violated [135 and 137]. Also, Wilcoxon Signed-rank test was used as the non-parametric equivalent of dependent t-test [138, 139] to carry out follow-up pair-wise comparisons across the experimental conditions in this experiment when p value in Friedman test is greater than 0.05. The obtained results were analysed in terms of the users' evaluation of facial expressions in face to face (video) and Avatar with body gestures and voice expression in synthesised speech used in the experimental platforms, answering time (efficiency), correctly answered questions (effectiveness) and user satisfaction. The significance level used in these statistical tests was $\alpha = 0.05$ indicating the existence of significant difference if p-value was less than that value [135].

4.9.1 Views of Users

4.9.1.1 Facial expression in the Face to Face platform

Figure 4.7 shows how users evaluated, positively or negatively, each facial expression used in this experiment, in the face to face platform. Apart from the neutral expression, it can be noticed that all the expressions were positively viewed by the users. More specifically, more than 70% of the participants believed that the positive expressions such as *neutral* and *thinking* could be used positively. The percentage for neutral expression reached to approximately 75% and thinking expressions to 81%. For the *unhappy* expression, the results were less significant with 64% positive users' views. On contrast, the *happy* expression reached about 69 % of users' positive views which means that users had a better impression. The significance of the difference between positive and negative views was examined by the Chi-square (x^2) test. Table 4.2 shows the x^2 values for all expressions. Positive expressions such as *neutral*, *happy*, and *thinking* obtained positive significant results whereas the unhappy expressions did not show any significance (see Appendix B3).

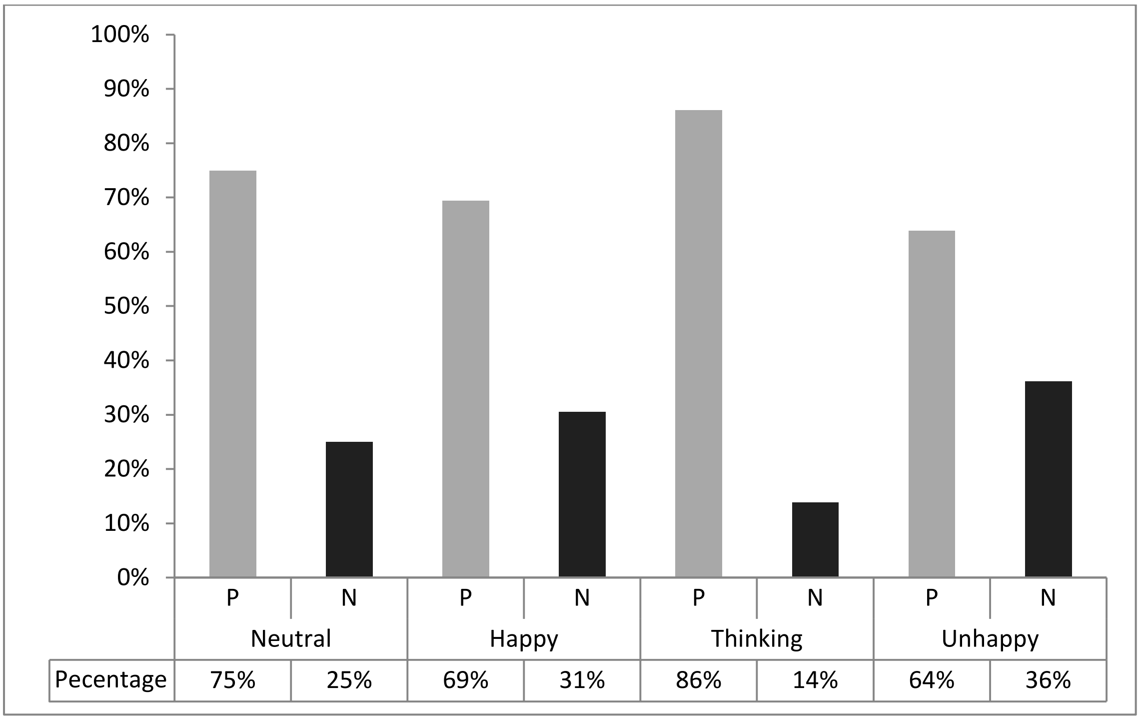


Figure 4.7: Views of users in the Face to Face platform (P= Positive and N= Negative).

Facial Expression	Chi-square value	Asymp. Sig.	P<0.05	Significance
Neutral	9.00	0.003	0.05	Yes
Happy	5.44	.020	0.05	Yes
Thinking	18.77	.000	<0.05	Yes
Unhappy	2.77	.096	>0.05	No

Table 4.2: Chi-square results for users' evaluation of facial expression used in Face to Face platform.

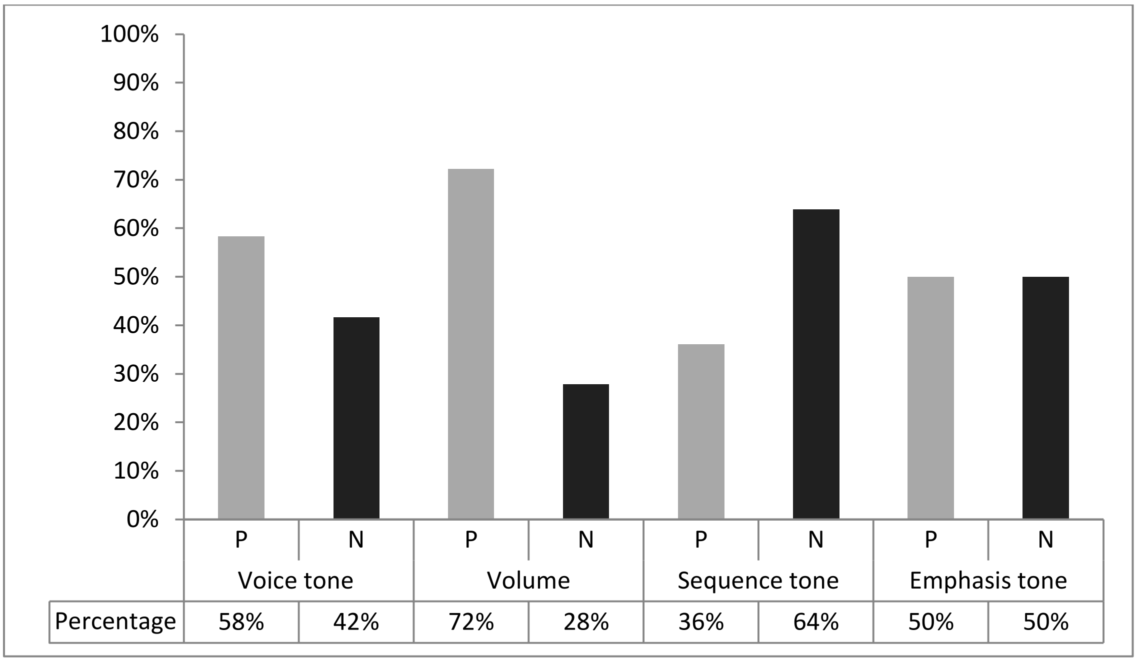


Figure 4.8: Views of users in the Synthesised Speech platform (P= Positive and N= Negative).

Voice Expression	Chi-square value	Asymp. Sig.	P<0.05	Significance
Voice tone	**1.00**	**0.317**	**0.05**	**No**
Volume	**7.11**	**0.008**	**0.05**	**Yes**
Sequence	**2.77**	**0.096**	**0.05**	**No**
Emphasis	**0.00**	**1.000**	**0.05**	**No**

Table 4.3: Chi-square results for users' evaluation of facial expression used in the synthesised speech platform.

4.9.1.2 Voice Expression in the Synthesised Speech Platform

Figure 4.8 shows the way that users evaluated, positively or negatively, each voice expression used in the synthesised speech platform experiment. It can be noticed that most voice expressions were negatively viewed by the users. More specifically, more than 40% of the participants believed that the following expressions such as *voice tone*, *sequence of tone* and *emphasis on tone* were used negatively by synthesised speech platform. The percentage for sequence of tone expression reached about 64% and emphasis on tone and voice tone expressions to about 50% and 42% respectively. For volume expression, the results were more significant with 72% positive users' views. The significance of the difference between positive and negative views was examined by the Chi-square (x^2) test. Table 4.3 shows the x values for all expressions. The expressions that had negative rate such as voice tone, sequence of tone and emphasis on tone demonstrated no significant results whereas the volume expressions show significance result (see Appendix B4).

4.9.1.3 Avatar Body Gestures Platform

Figure 4.9 shows the results of the same set of facial expressions after users had the opportunity to interact with face to face platform. Moreover, body gestures were evaluated in this part as well. It can be seen that users expressed a positive view to most of these expressions when being used in e-feedback interfaces provided in both face to face and avatar body gestures platforms.

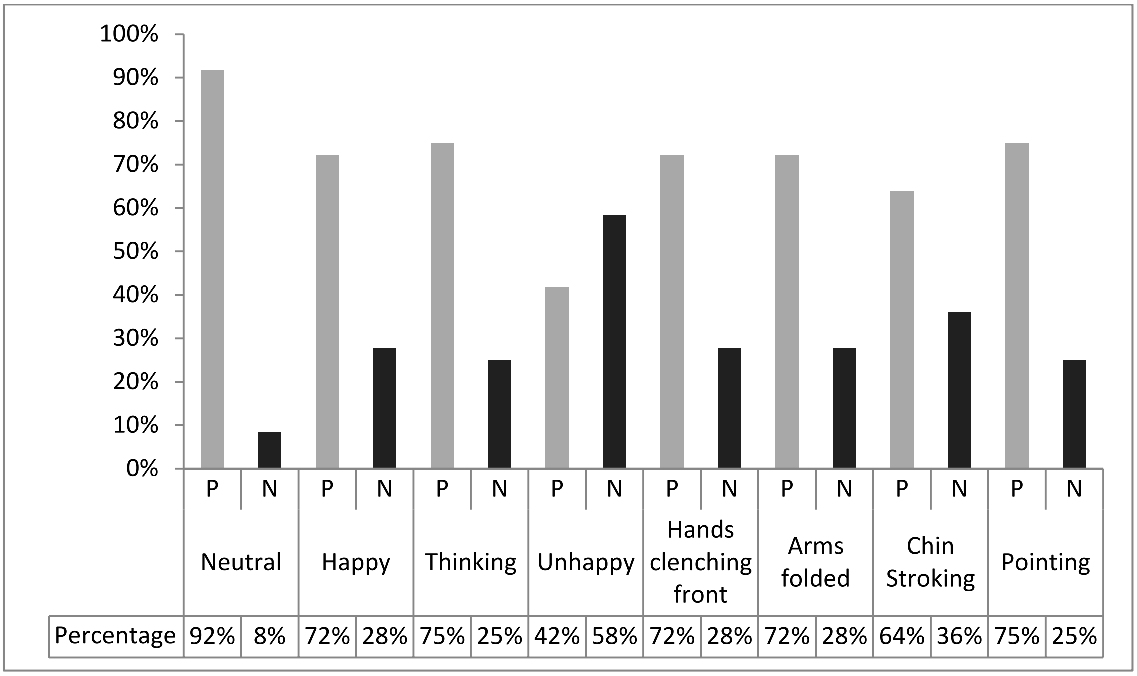


Figure 4.9: Views of users in the Avatar Body Gestures platform (P= Positive and N= Negative).

Facial Expression and Body Gestures	Chi-square value	Asymp. Sig.	P<0.05	Significance
Neutral	25.00	.000	<0.05	Yes
Happy	7.11	.008	<0.05	Yes
Thinking	9.00	.003	<0.05	Yes
Unhappy	1.00	.317	>0.05	No
Hands clenching-front	7.11	.008	<0.05	Yes
Arms folded	7.11	.008	<0.05	Yes
Chin Stroking	2.77	.096	>0.05	No
Pointing	9.00	.003	<0.05	Yes

Table 4.4: Chi-square results for users' evaluation of facial expression used in Avatar Body Gestures platform.

As part from the neutral expression, it can be noticed that all the expressions were positively viewed by the users. More specifically, more than 70% of the participants believed that the positive expressions such as *neutral, happy* and *thinking* could be used positively by an expressive avatar. The percentage for the neutral expression reached about 92% and thinking and happy expressions to about 75% and 72% respectively. For the unhappy expression, the results were less significant with 58% negative users' views. This means that over 50% of users disliked unhappy expression on avatar body gestures. The significance of the difference between positive and negative views was examined by the Chi-square (x^2) test. Table 4.4 shows the x values for all expressions. Positive expressions such as neutral, happy, and thinking obtained positive significant results whereas the unhappy expressions did not show any significance.

Figure 4.9 shows users' evaluation of the body gestures when presented to users. For positive group, it can be seen that these body animations were evaluated positively. The *pointing* gesture obtained 75% positive score, followed by hands clenching gesture at 72%. A lower positive score was observed for *chin stroking* (64%). However, *arms folded* which has been supposed to be a negative gesture was perceived positively by 72% of users. As can be seen in Table 4.4, each of pointing, chin stroking, and arms folded obtained positive significant ratings. However, the chin stroking gesture, although is classified as positive, demonstrated negative significant results (see Appendix B5).

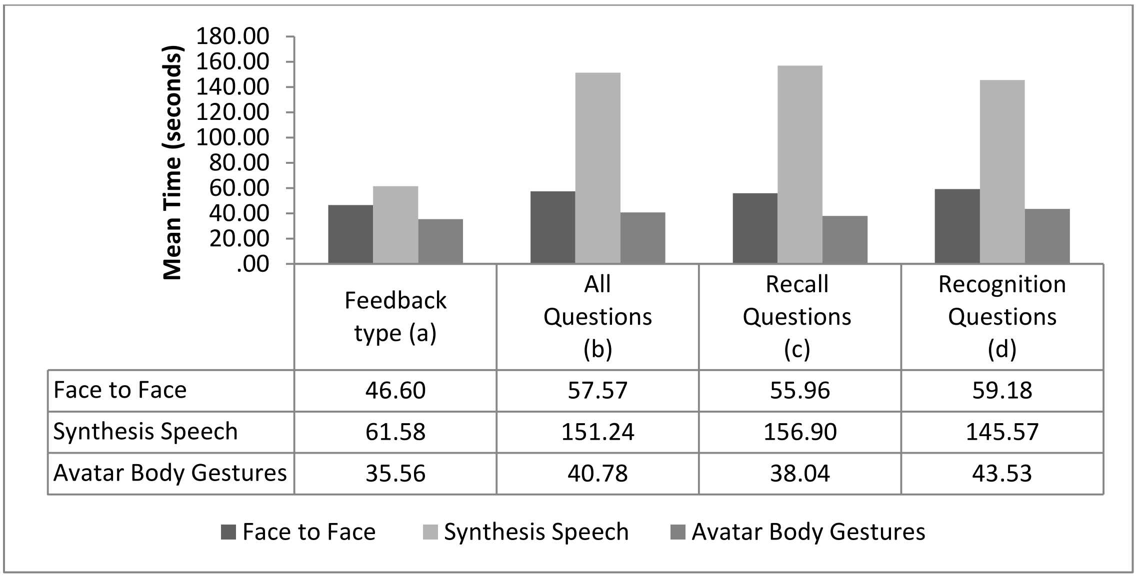
4.9.2 Efficiency

4.9.2.1 Feedback type

Efficiency of each experimental platform was measured using the time taken by users to watch or listen to the feedback type when presented by that platform. Figure 4.10a shows the mean value of watching or listening time for all feedback types for each experimental condition. It can be noticed that the watching or listening time was the least with the avatar and body gestures platform (see also Appendix B6).

4.9.2.2 Feedback questions type

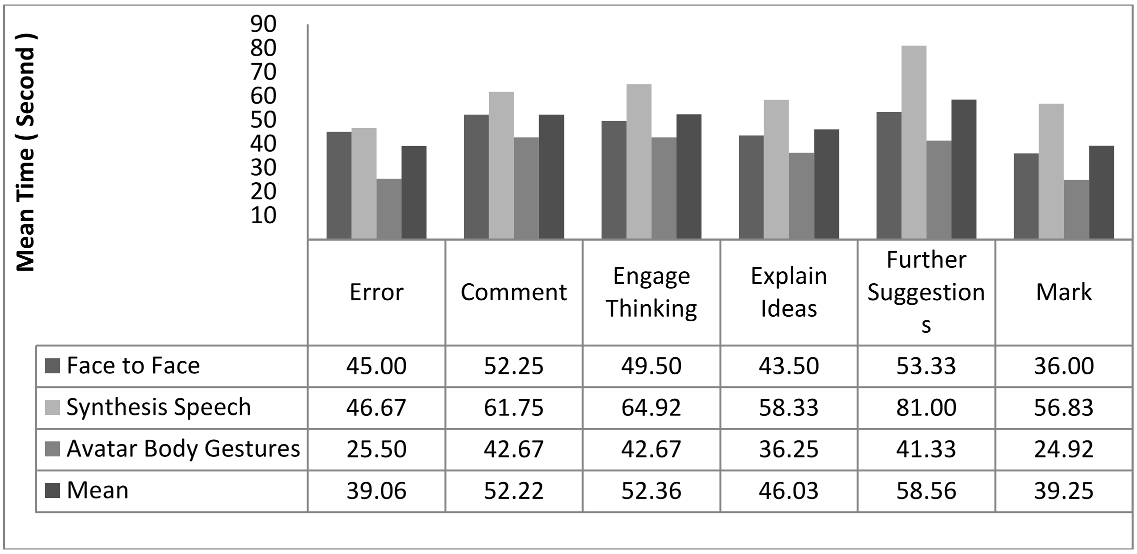
A total of 12 questions were required to be answered by each user. They were equally distributed over the six feedback types. On overall, each lesson was presented 12 times



	Feedback type (a)	All Questions (b)	Recall Questions (c)	Recognition Questions (d)
Face to Face	46.60	57.57	55.96	59.18
Synthesis Speech	61.58	151.24	156.90	145.57
Avatar Body Gestures	35.56	40.78	38.04	43.53

Figure 4.10: Mean values of time of all feedback type (a), all questions (b), feedback recall questions (c), feedback recognition (d).

by each platform (see Table 4.1). Therefore, the time to answer each question was observed 12 times with each platform. The mean total time taken to answer all the questions was 57.57 seconds in the face to face platform compared to 151.24 seconds in the synthesised speech platform and 40.78 seconds in the avatar and body gestures platform. It can be observed from Figure 4.10b that the avatar and body gestures platform was the most efficient platform averaging 40.78 seconds answering time per user, followed by the face to face 57.57seconds and the synthesised speech which was found to be the least efficient platform with 151.24 seconds.



	Error	Comment	Engage Thinking	Explain Ideas	Further Suggestion s	Mark
Face to Face	45.00	52.25	49.50	43.50	53.33	36.00
Synthesis Speech	46.67	61.75	64.92	58.33	81.00	56.83
Avatar Body Gestures	25.50	42.67	42.67	36.25	41.33	24.92
Mean	39.06	52.22	52.36	46.03	58.56	39.25

Figure 4.11: Mean Time of each feedback type for each interface.

Statistical calculations, using the Friedman's ANOVA test, demonstrated significant differences in answering time by users among the three experimental platforms. In other words, the time users spent in answering the required questions was significantly affected by the presentation mode ($x^2(2)$ = 201.3, CV = 5.99, p < .05). See also Appendix B7.

4.9.2.2.1 Feedback Recalls Questions

In figure 4.10c it can be noticed that the mean time to answer feedback recall questions were the lowest in the avatar and body gestures platform which was 38.04 seconds. It was followed by the face to face and synthesised speech platforms, 55.96 and 156.90 seconds respectively. This means that users took less time when they used the avatar and body gestures platform to answer feedback recall questions. Refer to appendix B7 for raw data of each user.

4.9.2.2.2 Feedback Recognition Questions

By comparing between the time spent by users to answer feedback recall questions and feedback recognition questions, the time spent in feedback recognition question is higher. Figure 4.10d shows that the avatar and body gestures platform is significant as shown in Table 4.5. The time spent by users in the synthesised speech platform to answer feedback recognition questions is about three times more than the time spent in the face to face and avatar body gestures platforms.

4.9.2.3 Feedback Type

Figure 4.11 shows the mean time taken by users to watch or listen to each feedback types grouped according to the experimental platforms.

In each feedback, it can be noted that users were the easiest in watching or listening when tutor with avatar body gestures was used and the difficult when feedback represented with synthesised speech was used. Nevertheless, the average watching or listening time was approximately similar at 39.06 seconds for *error*, 52.22 seconds for *comment*, 52.36 seconds for *engage thinking*, 46.03 seconds for *explain ideas*, 58.56 seconds for *further suggestions* and 39.25 seconds for *mark*.

Time	Chi-square value	Asymp. Sig.	Significance
All Feedback type	60.1	0.000	Yes
All questions	201.3	0.000	Yes
Recall questions	111.1	0.000	Yes
Recognition questions	90.8	0.000	Yes
Feedback Type			
Error	9.6	0.008	Yes
Comment	8.7	0.013	Yes
Engage Thinking	6.0	0.050	No
Explain Ideas	11	0.004	Yes
Further Suggestion	10.7	0.005	Yes
Mark	18.5	0.000	Yes
Feedback Recall Question			
Error	22.2	0.000	Yes
Comment	20.7	0.000	Yes
Engage Thinking	19.5	0.000	Yes
Explain Ideas	16.2	0.000	Yes
Further Suggestion	19.5	0.000	Yes
Mark	20.7	0.000	Yes
Feedback Recognition Question			
Error	13.5	0.001	Yes
Comment	16.2	0.000	Yes
Engage Thinking	20.7	0.000	Yes
Explain Ideas	15.5	0.000	Yes
Further Suggestion	10.2	0.006	Yes
Mark	20.7	0.000	Yes

Table 4.5: Chi-square results for time of feedback type and feedback questions used in all platforms.

In the avatar and body gestures platform, watching or listening to error and mark feedback, time was lower than the rest of feedback types. Difference level in time spent by users between all experiment was at significance level for all feedback types except engage thinking (see Tables 4.5).

4.9.2.4 Feedback Type with Recall and Recognition Questions

Figure 12 shows the mean time taken to answer each question type of each feedback type in each interface. Table 4.5 presents significance levels for all experimental platforms for each feedback type with recall and recognition questions at 0.05. The shortest answering times were found for recall question related to error with 23.75 seconds in avatar body gestures platform (minimum value), 26.38 seconds in avatar and body gestures for recognition questions and 30.17 seconds in Avatar body gestures platform for recall questions in engage thinking. On the other hand, the longest answering times were observed in the recognition question of the engage thinking with 182.42 seconds in synthesised speech platform, 187.50 seconds in synthesised speech platform for recall question for further suggestion, and in synthesised speech platform for 188.08 seconds in recall question for explain ideas (maximum value).

4.9.3 Effectiveness

The measure of effectiveness of the experimental platforms was specified according to the number of correct answers achieved by users when each of these platforms has delivered the feedback types. Figure 4.13a shows the percentage of correct answers for all questions. Figure 4.13 groups results by question type in each experimental condition. It can be seen that users' act was the highest with the implementation of avatar body gestures platform.

4.9.3.1 Feedback Questions

There were 12 questions for each user equally distributed on the experimental platforms at 2 questions relating to each feedback type. Each platform was used 12 times to introduce each feedback type (refer to Table 4.1). Therefore, the maximum number of correct answers that can be accomplished by the users in each experimental condition was 144 (12 * 2 questions per feedback * 6 feedback types).

As can be seen in Figure 4.13, the avatar body gestures platform outperformed the other two conditions, face to face and synthesised speech platforms. Using the avatar body gestures platform, 80% users correctly answered compared to 70% using the face to face platform and 47% using the synthesised speech platform. Friedman‘s ANOVA revealed that the difference in users' performance among the experimental conditions was significant ($x^2(2) = 41.3$, CV = 5.99, $p < .05$) indicating that the presentation mode significantly influenced users‘ ability to answer the essential questions correctly.

4.9.3.1.1 Feedback Recall Questions

For each feedback type, the questions were of two types; recall and recognition. Each of these questions has been asked 12 times with each platform. As a result, the total number of questions in each type was 72 (12 * 1 question per type * 6 feedback types).

In recall questions, Figure 4.13b demonstrates that users' performance was better when using avatar body gestures platform compared to the other presentation modes.

Using the body gestures platform, the correct answers by users to recall questions was 78% whereas a smaller number of correct answers to the same type of questions was observed when using the face to face platform (71%).

When the synthesised speech platform shared the delivery of the feedback, users' achievement dropped further to 49%. Based on the Friedman's ANOVA calculations, users performed significantly differently amongst the three platforms with regard to recall questions ($x^2(2) = 15$, cv = 5.99, $p < .05$). See also Table 4.6.

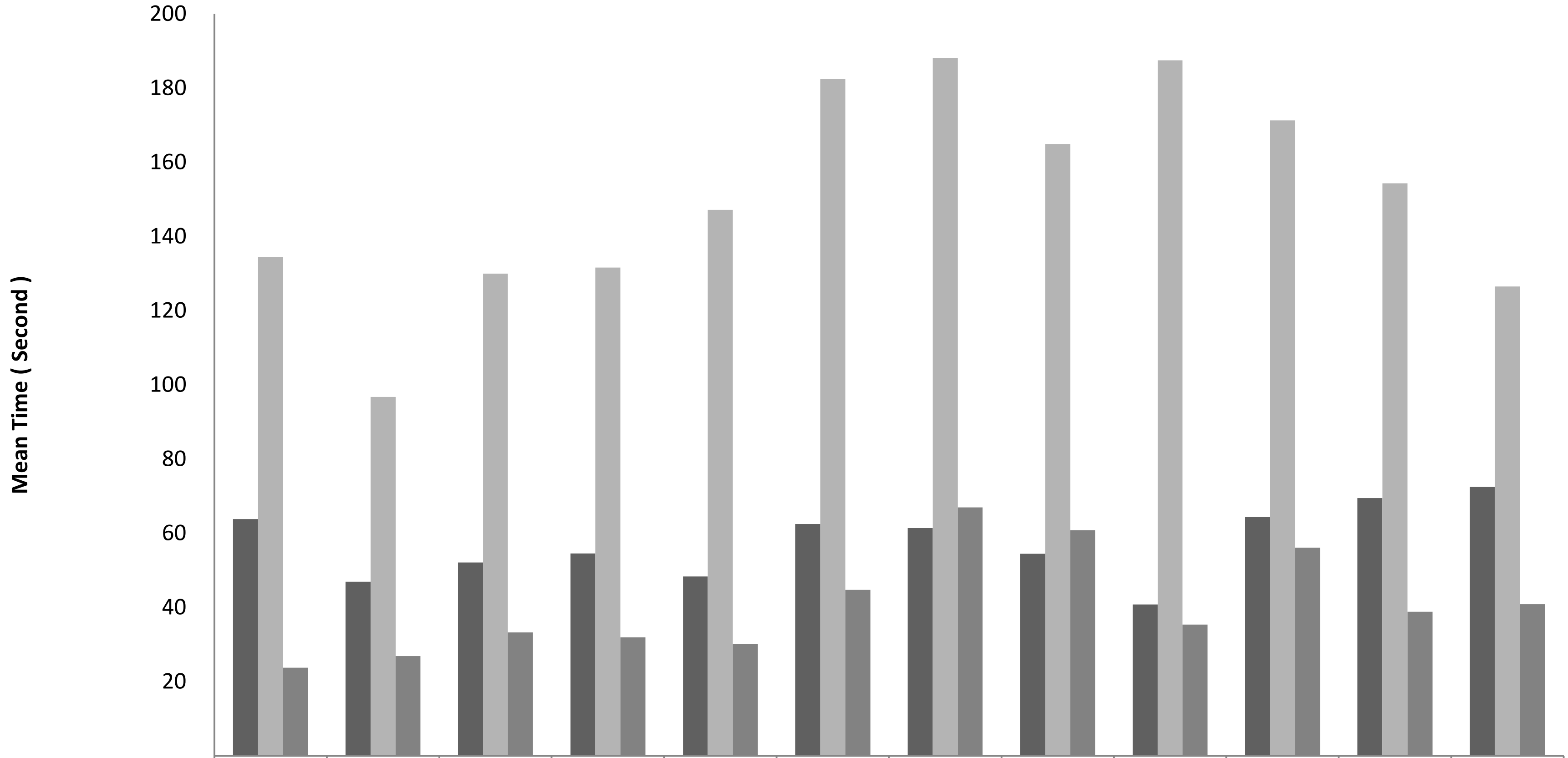
4.9.3.1.2 Feedback Recognition Questions

Although users' performance was better in the recognition questions, the presentation mode also showed overall significant differences among the experimental conditions in the answers of users in this type of questions ($x^2(2) = 27.7$, cv = 5.99, $p > .05$). Therefore, the users' performance in answering the recognition questions was significantly affected by the presentation modes offered in the experimental interfaces.

Nevertheless, avatar body gestures platform scored the highest percentage of users' correct answers (86%) compared to face to face platform (69%) and the synthesised speech platform (46%).

4.9.3.2 Feedback Type

A comparison between users' performance in the six feedback types is shown in Figure 4.14. It can be observed that users performed better when each of the feedback was presented by the avatar and body gestures platform where the percentage of correctly answered questions varied between 75% and 88%. In the error and engage thinking feedback, this percentage ranged from 46% to 75% when both feedback were presented by the face to face and synthesised speech platforms; however higher percentages were noted for avatar body gestures platform in both the error and engage thinking feedback. In converse, the face to face platform condition scored 63% correct answers in the explain ideas outperforming the synthesised speech platform with 54%. Calculating the mean values, users achieved 55% correct answers in explain ideas, whilst the highest user performance was found to be 74% in error feedback.



	Error Recall	Error Recognition	Comment Recall	Comment Recognition	Engage Thinking Recall	Engage Thinking Recognition	Explain Ideas Recall	Explain Ideas Recognition	Further Suggestions Recall	Further Suggestions Recognition	Mark Recall	Mark Recognition
Face to Face	63.83	46.92	52.08	54.50	48.33	62.50	61.33	54.42	40.75	64.33	69.42	72.42
Synthesis Speech	134.42	96.75	129.92	131.58	147.17	182.42	188.08	164.92	187.50	171.25	154.33	126.50
Avatar Body Gestures	23.75	26.83	33.25	31.92	30.17	44.67	66.92	60.83	35.33	56.08	38.83	40.83

Figure 4.12: Mean Time of each feedback type with recall and recognition questions.

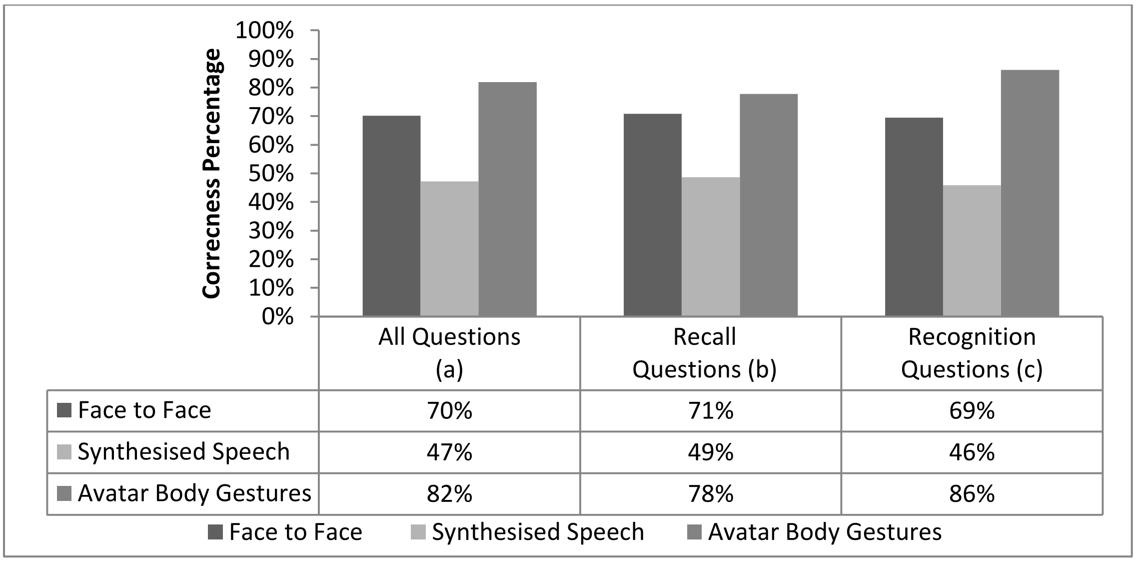
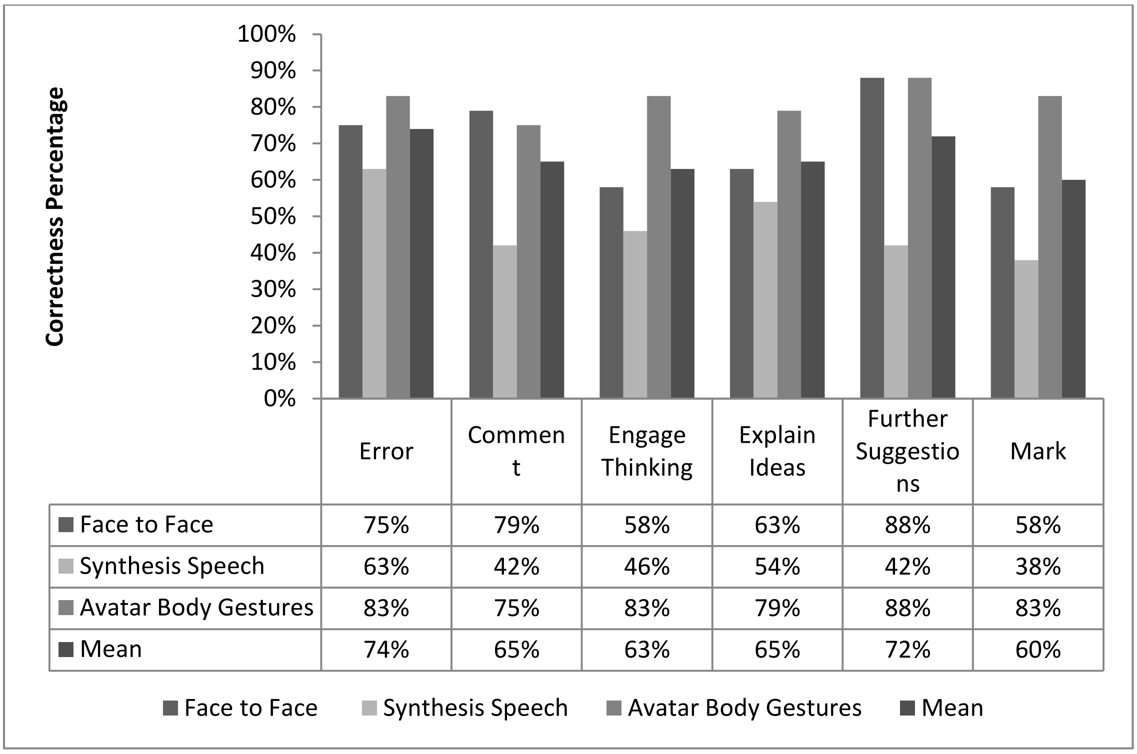


Figure 4.13: Correctness percentage of all questions (a), feedback recall questions (b), feedback recognition questions (c).

Correct answers of users	**Chi-square value**	**Asymp. Sig.**	**Significance**
All questions	41.3	0.000	Yes
All recall questions	15	0.001	Yes
All recognition questions	27.7	0.000	Yes
Feedback Type			
Error	3.45	0.178	No
Comment	8.1	0.017	Yes
Engage thinking	7.9	0.019	Yes
Explain Ideas	3.5	0.174	No
Further Suggestion	15	0.001	Yes
Mark	10.7	0.005	Yes
Feedback Recall Question			
Error	1.33	0.513	No
Comment	6.3	0.044	Yes
Engage thinking	2.6	0.273	No
Explain Ideas	0.286	0.867	No
Further Suggestion	4.7	0.097	No
Mark	3.25	0.197	No
Feedback Recognition Question			
Error	2.8	0.247	No
Comment	2.6	0.273	No
Engage thinking	6.33	0.042	Yes
Explain Ideas	4.7	0.097	No
Further Suggestion	12.3	0.002	Yes
Mark	8.7	0.013	Yes

Table 4.6: Chi-square results for correct answers of feedback type and feedback questions used in all platforms.



	Error	Comment	Engage Thinking	Explain Ideas	Further Suggestions	Mark
Face to Face	75%	79%	58%	63%	88%	58%
Synthesis Speech	63%	42%	46%	54%	42%	38%
Avatar Body Gestures	83%	75%	83%	79%	88%	83%
Mean	74%	65%	63%	65%	72%	60%

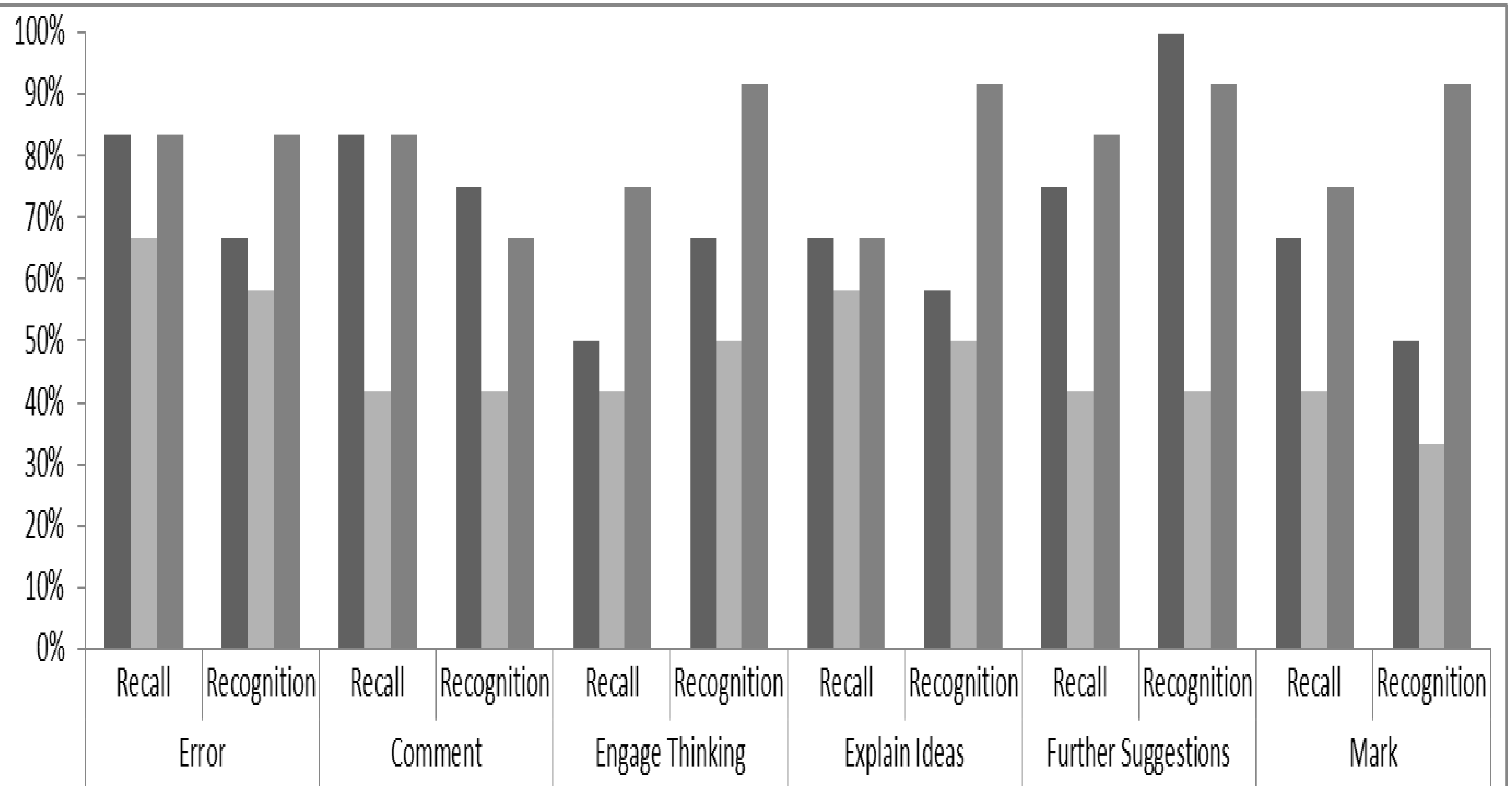
Figure 4.14: Correct answers of each feedback type for each interface.

4.9.3.3 Feedback type with Recall and Recognition Questions

The percentages of correct answers that users achieved for each question using each platform in the presentation of the feedback types are displayed in Figure 4.15. On overall, the average percentages for correct answers across the six feedback types using avatar body gestures platform were 92% for Engage Thinking, Explain Ideas, Further Suggestions and Mark recognition question, 83% for Error, and Comment recall and recognition question. In regard to the use of the face to face platform and synthesised speech platform, the overall percentage dropped dramatically particularly for recall questions.

4.9.4 Satisfaction

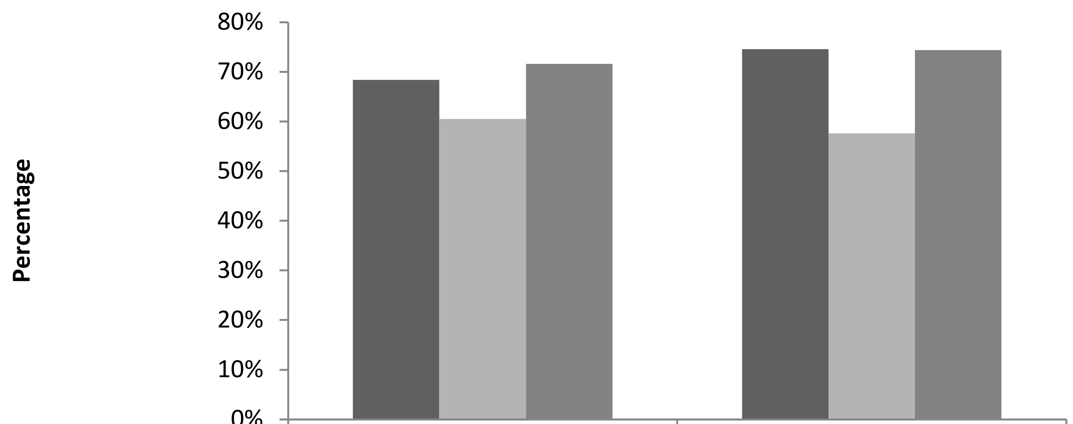
Users' responses to System Usability Scale (SUS) questionnaire (10 statements) was used to measure users' attitude after they have had the opportunity to use each experimental platform. Also, users were required to respond to additional eight statements relating to the interface components and learning experience (see Figure 4.16). Each of the 18 statements was based on a five-point Likert scale where 1 represents strongly disagree and 5 represents strongly agree.



	Error		Comment		Engage Thinking		Explain Ideas		Further Suggestions		Mark	
	Recall	Recognition	Recall	Recognition	Recall	Recognition	Recall	Recognition	Recall	Recognition	Recall	Recognition
Face to Face	83%	67%	83%	75%	50%	67%	67%	58%	75%	100%	67%	50%
Synthesis Speech	67%	58%	42%	42%	42%	50%	58%	50%	42%	42%	42%	33%
Avatar Body Gestures	83%	83%	83%	67%	75%	92%	67%	92%	83%	92%	75%	92%

Figure 4.15: Correctness percentage of each feedback type with recall and recognition questions.

SUS scoring method [140] was used for the first ten statements to calculate the satisfaction score for each user in each interface, whereas frequency of users' agreement for each statement was used to attain their level of attitude towards different aspects and learning experience of the tested platforms. Findings demonstrated that the Avatar and body gestures platform scored the highest satisfaction rate compared to face to face and synthesised speech platforms. The mean SUS score calculated for the Avatar body gestures platform found 72 compared to 68 and 61 for Face to face platform and Synthesised speech platform respectively. Statistical calculations using Friedman's ANOVA showed an overall no significance in terms of differences in users' attitudes towards different presentation modes ($x^2(2) = 2.9$, CV = 5.99, $p > .05$). So, Wilcoxon test was used to find out which platform scores has significant between each other. Z value between face to face and synthesised speech platforms is -1.962 and between face to face and avatar body gesture platform is -0.739 but between Avatar body gestures and synthesised speech platforms is -2 which is significant. As result Avatar body gestures score of first ten statements is highest score as shown in Figure 17.



	SUS 1-10	SUS 11-18
Face to Face	68%	75%
Synthesis Speech	61%	58%
Avatar Body Gestures	72%	74%

Face to Face Synthesis Speech Avatar Body Gestures

Figure 4.16: Users' agreement for each System Usability Scale (SUS) statement, SUS 1-10 user attitude about interfaces and SUS 11-18 user agreement about interface components and learning experience.

Variables	Chi-square value	Asym. Sig.	Significance
SUS 1-10	2.9	0.238	No
SUS 11-18	6.4	0.041	Yes

Table 4.7: Chi-square results for user's agreement.

Variables	Z value	Asymp. Sig.	Significance
Synthesised Speech Satisfaction – Face To Face Satisfaction1	-1.962[a]	.050	No
Avatar Body Gestures Satisfaction1 – Face To Face Satisfaction1	-.736[b]	.462	No
Avatar Body Gestures Satisfaction1 – Synthesised Speech Satisfaction1	-2.000[b]	.046	Yes

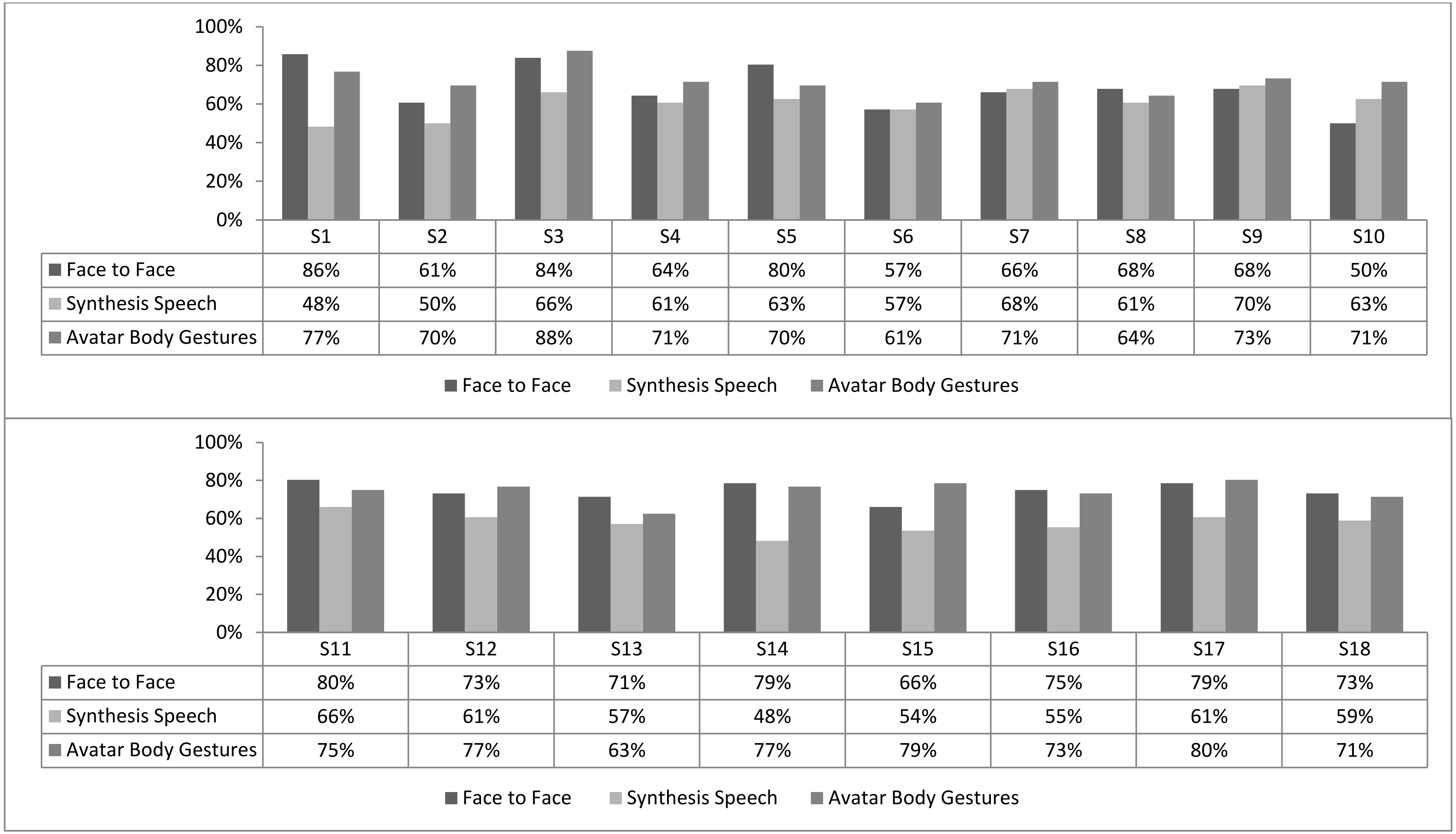
Table 4.8: Z value for user's agreement when p is not significant in Table 4.7.

4.9.5 Post-Experimental Views of Users

At the end of the experiment, users were required to rate the usefulness of each platform used on a 5-point Likert scale with 1, the value of least useful and 5, the value of most useful. Also, users had to indicate the most preferred platform. Figure 4.18 shows that the face to face platform was found to be more notable than using avatar body gestures platform as the observed most preferable rate was about 50% for avatar body gestures platform and for face to face platform and synthesised speech platform are about 15% and 8% respectively. In comparison, employing facial expressive with body gestures were found to be the most useful for users where exactly half of them (50%) consider their engagement with feedback to be considerably supported by this mode of performance.

4.10 Discussion

The results demonstrated in Figures 4.1 and 4.3 showed that facial expressions have been highly regarded by users (happy was rated significantly high). The percentage of positive rating for this expression is about 69%. On the other hand, the neutral expressions were found to be the most positively viewed by the users with about 86% for thinking and 75% for neutral. Chi-square test results shown in Table 4.1 confirmed what has been hypothesized in H1 where the neutral and positive expressions attained significant levels of users’ acceptance. These findings provide additional support to H1.



	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Face to Face	86%	61%	84%	64%	80%	57%	66%	68%	68%	50%
Synthesis Speech	48%	50%	66%	61%	63%	57%	68%	61%	70%	63%
Avatar Body Gestures	77%	70%	88%	71%	70%	61%	71%	64%	73%	71%

	S11	S12	S13	S14	S15	S16	S17	S18
Face to Face	80%	73%	71%	79%	66%	75%	79%	73%
Synthesis Speech	66%	61%	57%	48%	54%	55%	61%	59%
Avatar Body Gestures	75%	77%	63%	77%	79%	73%	80%	71%

Figure 4.17: Rate of users' agreement for each SUS1-10 and SUS11-18 statements.

When the tested expressions have been used interactively by video in both face to face and avatar body gestures platforms, it was observed in favour of positive views (Figure 4.1). Combining these expressions in an interactive e-feedback interface impressed the This has been evidenced by users' views which became significantly positive with respect to all of the expressions except the unhappy (see Table 4.1), although this expression scored the highest shift in users' views. So, the first hypothesis of the experiment has been accepted. As predicted in the third hypothesis, Figure 4.3 shows a higher positive rating for most gestures when it has been used by the avatar body gestures platform. In particular, users' thought about the *chin stroking* was changed but not significantly. However, the remaining positive gestures scored significant positive ratings (see Table 4.3). Users felt that these body animations could attract them, increase their attention about the feedback types presented, and let them feel as getting feedback from a tutor or instructor. Therefore, the obtained results expressed users' belief that these body animations have the capability to be used in delivering e-feedback. Furthermore, users' opinions showed that most body gestures such as *arm pointing* and *hand clenching –front should* be used by the lecturers as these gestures were significantly positively perceived. In general, the experimental results as demonstrated in Tables 4.1 and 4.3 suggest that specific facial expressions and body gestures could be more attractive for students however some other expressions are not suitable.

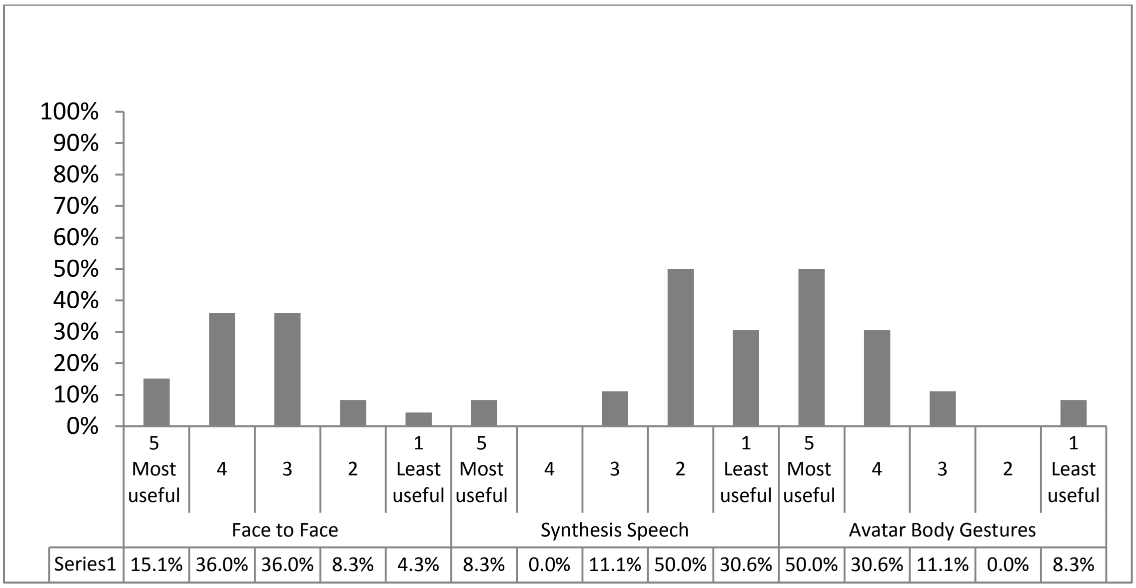


Figure 4.18: User's rate of each platform used.

It was assumed that voice expression will be rated negatively in H3. The synthesised speech usually used to give instructions to users and it should be used for short statements. The result were not significant (see Table 4.2) for the most voice expression used to communicate e-feedback. Sequence of tone was rated negative by the most users (64%). While the rate of the remaining voice expressions were close to each other. On the other hand, volume expression was the only significant positive rate. On the whole, it is clear these result support the H3.

This Chapter also investigated three different methods to deliver different types of feedback. Specifically, these methods were face to face, synthesised speech and avatar body gestures platforms. The achieved results were used to compare these experimental conditions in terms of efficiency, effectiveness and user satisfaction.

The difference among the experimental platforms; face to face, synthesised speech and avatar body gestures with respect to each of these usability factors has been predicted in the hypotheses H4. In answering the required feedback questions, the users of the experiment spent different times performing different methods offered by the experimental interfaces. Also, the number of questions that were answered correctly and the satisfaction of users varied across these interfaces. This difference was found to be significant by Friedman's ANOVA calculations. As a result of multiple assessments, the avatar body gestures platform was found to be the most efficient and most effective as well as the most satisfactory presentation mode. The way used in avatar body gestures platform to deliver feedback types facilitated the students to be engaged in feedback session similar to a real lecturer-to-student human interaction. In addition, when the full body of speaking avatar lecturer was animated, users were more involved and engaged with the interaction. Moreover, delivering the feedback types in the background of the avatar lecturer within the same interface component in avatar body gestures platform helped users to watch both at the same time. This means that the users can see their feedback as text with the original course work while the avatar animates. Also, users engaged with cognitive processing of the delivered feedback that led to a better user understanding. This situation enabled the users to preserve the communicated information and accordingly, the time they spent in responding to the required questions was significantly shortened in comparison with using facially expressive talking head of face to face platform. Additionally, avatar body gestures platform significantly outperformed the other two experimental conditions in terms of correct answers and user satisfaction. Moreover, the experimental results shown in Figure 4.18 demonstrated how users rated the avatar body gestures platform to be the most useful interface.

The comparison between face to face and avatar body gestures platforms revealed that usability levels were equivalent. However, it was significant even though, using avatar body gestures performed better than using face to face and their usefulness was rated higher as shown in Figure 4.18. During the experiment, it was perceived that users' attention was increased with the use of avatar body gestures platform. However, incorporating talking head of face to face with facial expressions in an interface component different from that used to present the textual feedback (as applied in avatar body gestures platform) did not appeal users as much as the avatar body gestures platform.

According to Figures 4.10b and 4.13, efficiency and effectiveness of the experimental platforms were different in favor to the feedback question type. There was a difference across these conditions in the time users took in answering both feedback recall and recognition questions. Similar difference was also noticed in the number corrected answers to both types of questions. These differences were found to be significant for the feedback recall and recognitions questions.

On overall, it was noticed that the users spent less time in answering the recognition question than the time they needed in responding to the recall questions (see Figure 4.10b). The mean time that users spent to answer feedback recognition questions was 82.78 and for recall questions was 83.63. However, lower time was spent by users to answer questions in feedback recall questions in synthesised speech and avatar body gestures platforms. In recognition questions, users were required to select the answer from a list of options that may have contributed to reduce the time they required to answer question. In recall questions, users may have taken more time in trying to recall from memory the required information. Also, the percentage of correctly answered recognition questions was noted larger in comparison with the recall questions as shown in Figure 4.13. The average percentage of feedback questions that were answered correctly was higher in recognition questions (67%) than recall questions (66%). In recognition questions, users selected the correct answer from the given alternatives and this could be due to chance. The list of alternative answers makes it easier for users to answer correctly. On the other hand, in recall questions, no answering options were provided and this might make it more difficult to answer. In this case, users had to depend only on their memory to get the correct answer.

With respect to the last experimental hypothesis H4, users' attitude to each experimental platform was found significantly different confirming what has been hypothesised. In accordance with the post hoc statistical tests applied on the SUS satisfaction questionnaire, the avatar body gestures platform was significantly more satisfactory to users compared to the face to face and the synthesised speech platforms. Also, the satisfaction results shown in Figure 4.17, offered additional support to H4. The design of this experiment involved employing one group of users to evaluate all the experimental conditions. In other words, each user had the opportunity to interact with each of the tested experimental platform. Users were impressed and satisfied with the different aspects of the avatar body gestures platform as well as to the learning experience they gained using this platform.

4.11 Conclusion

This Chapter documented the experimental work conducted to innovatively explore users' views in regards to a specific set of facial expressions and body gestures (neutral, happy, thinking, hand clenching, arms folded, chin stroking and arms pointing) when used to deliver different feedback types in an e-feedback interface. Also, it investigated usability aspects and the engagement of users with feedback in platforms that presented feedback types through three different e-feedback interfaces. The first interface incorporated face to face (video) facially expressive while the second interface made use of synthesised speech with text. In the third interface, interface made use of half body animated avatar with facial expressive. The assessed usability measures included efficiency where task is measured in completing time, effectiveness where task is measured correctly completed and user satisfaction.

The achieved results confirmed that facial expressions and body gesture usually considered as positive were also regarded positively by the users. These findings recommend the implementation of these expressions and gestures in the design of avatars in order to show a pleasant and attractive character as tutor. Also, the results of this experiment provided realistic suggestion that using half body animation of speaking virtual tutor combined with the feedback in text at the same interface is more efficient, more effective and more satisfactory as opposed to the other two investigated e-feedback interfaces. In regard to specific types of the feedback (i.e. Error and Further Suggestions), the multimodal audio-visual presentation of the feedback types as applied in the avatar body gestures platform, also, feedback questions types (feedback recall question and feedback recognition questions). However, the results appeal to additional questions such as: would the adding auditory non-speech metaphors to avatar body gestures platform enhance the student's engagement with different feedback types. This will be investigated more in next experimental stage.

Finally this Chapter described the second experimental stage that has been conducted to explore and compare the role of avatars when incorporated as virtual lecturers in e-feedback interfaces to present six different feedback types. Incorporating textual and graphical communication metaphors, also synthesised speech and animated speaking avatars were employed in three different modes of presentation which are speaking video with facial expressions in Face to Face platform, speaking using synthesised speech with text platform and speaking avatars with facial expressions and body gestures platform. The collection of experimental data was mainly based on two resources; observations and questionnaires, the assessed usability measures included efficiency (where a task is measured in terms of completion time), effectiveness (where a task is measured in terms of being successfully completed) and user satisfaction. The obtained results were analysed in terms of the users' evaluation of facial expressions in face to face (video) and Avatar with body gestures and voice expression using synthesised speech in the experimental platforms, answering time (efficiency), correctly answered questions (effectiveness) and user satisfaction.

The achieved results confirmed that facial expressions and body gesture usually considered as positive were also regarded positively by the users. The results suggest that specific facial expressions and body gestures could be more attractive for students however some other expressions could be not suitable for them. The avatar body gestures platform was found to be the most efficient and most effective as well as the most satisfactory mode of presentation. In addition, when the full body of speaking avatar lecturer was animated, users were more involved, more happy and concerned about the interaction. Results also showed that the usability levels of face to face and avatar body gestures platforms were equivalent. However, incorporating talking head of face to face with facial expressions in an interface component different from that used to present the textual feedback (as applied in avatar body gestures platform) did not appeal to users as much as the avatar body gestures platform. In overall, avatar body gestures platform was significantly more satisfactory to users comparable to the face to face and the synthesised speech platforms users and supported them to assess them. Therefore, they valued the role that could play in e-feedback interfaces.

Chapter 5

Effect of Earcons and Auditory Icons in Expressive Avatars to Communicate e-Feedback

5.1 Introduction

This Chapter investigates the addition of auditory non-speech metaphors to Avatar Body Gestures Platform in order to increase the engagement of users with feedback. In Chapter 4, the Avatar body Gestures Platform outperformed and delivered different feedback types efficiency and effectiveness. However, further investigation needed to measure achievement level of receiving feedback types. Also, this Chapter investigates the effect of using auditory non-speech sounds in Avatar Body Gestures Platform on students' engagement.

5.2 Aims

The aims of this chapter are:

1- Investigate the effect of using earcons and auditory icons and feedback types on user engagement in avatar body gestures platform.
2- Investigate the applicability of different earcons with the feedback types used in avatar body gestures platform and their influence on user engagement.
3- Examine the use of auditory icons to communicate feedback types in avatar body gestures platform and their influence on user engagement.
4- Examine the relationship between feedback types and user engagement in terms of using a variety earcons and auditory icons.
5- Measure the engagement of users by using earcons and auditory icons.

5.3 Objectives

In order to achieve the aims, the following objectives were required to be accomplished:

1. Design and implement of an experimental e-feedback interface that employs avatars body gestures in a similar way to that applied in the previous experiment but with the addition of earcons and auditory icons as non-speech auditory memos to link definite structures feedback types. This platform is referred to as Auditory Avatar Body Gestures Platform.
2. Empirical evaluation of the Auditory Avatar Body Gestures Platform by one group of users.
3. Measure the achievement level by calculating the percentage of questions successfully answered by users in order to measure the effectiveness of the tested e-feedback interface.
4. Measure the student's engagement of tested non-speech metaphors by users' ability to engage with presented feedback types.
5. Measure the satisfaction of users by their responses to questionnaire dedicated to assess users attitudes in relation to the applied e-feedback interface.

5.4 Hypotheses

It was expected that the addition of earcons and auditory icons in Auditory Avatar Body Gestures Platform would influence the usability level and student's engagement of the Auditory Avatar Body Gestures e-feedback platform. Based on this hypothesis, the following hypotheses were derived:

H1 The addition of earcons and auditory icons will have an effect upon the improvement of the achievement level of the Auditory Avatar Body Gestures Platform in terms of feedback types correctly completed of both feedback question types; recall and recognition.

H2 Users of the Auditory Avatar Body Gestures Platform will successfully engage with feedback types when communicated by earcons and auditory icons.

H3 Users of the Auditory Avatar Body Gestures Platform will express positive views towards the use of earcons and auditory icons in terms of Irritation, Disappointment, Usefulness and Concentration.

H4 Users of the Auditory Avatar Body Gestures Platform will correctly engage with the non-speech sounds used to link with feedback types presented.

H5 On overall, users will be satisfied with the Auditory Avatar Body Gestures Platform.

5.5 Experimental Platform

The Avatar Body Gestures Platform used in earlier experimental work demonstrated better performance compared to Face to Face Platform and Synthesis Speech Platform regarding the usability. The Avatar Body Gestures Platform was found to be as usable as Face to Face Platform and Synthesis Speech Platform with respect to both efficiency and effectiveness in feedback recall and recognition questions. These experimental outcomes established the need for further enhancements in the Avatar Body Gestures Platform to investigate whether the addition of non-speech auditory stimuli could enhance student's engagement in feedback recall questions as well as feedback recognition questions. It has been shown in these sections [5.1, 5.2, 5.3 and 5.4] that using earcons usually enhance usability. In addition, it is successfully proven that auditory icons as non-speech sounds to recognise the information in the interfaces [5.5, 5.6, 5.7]. Thersefore, the experimental Avatar Body Gestures Platform recruited to carry out this investigation simulated and extended the Avatar Body Gestures Platform by including earcons and auditory icons to capture the users' attention towards the types of the feedback content when delivered by facial expressive and body animated virtual tutor. In other words, the use of these non-speech metaphors (i.e. earcons and auditory icons) was the only feature that distinguished Auditory Avatar Body Gestures Platform from Avatar Body Gestures Platform. Table 5.1 shows how earcons and auditory icons were used in the Auditory Avatar Body Gestures Platform to capture users' attention towards the types of the feedback content while being communicated by the facially expressive and body animated virtual tutor. It can be seen that these parts were grouped into 6 different types of feedback which are: Error, Comment, Engage Thinking, Explain Ideas, Further Suggestions and Mark. Therefore, three types of multimodal interaction metaphors were incorporated in this platform: visual-only metaphors (text which is feedback type content), audio-visual metaphors (speaking avatar with body gestures) and auditory ones (earcons and auditory icons).

<table>
<tr><th></th><th colspan="6">Important Feedback level</th></tr>
<tr><th></th><th colspan="2">High</th><th colspan="2">Medium</th><th colspan="2">Low</th></tr>
<tr><td>Feedback types</td><td>Error</td><td>Comment</td><td>Engage Thinking</td><td>Explain Ideas</td><td>Further Suggestions</td><td>Mark</td></tr>
<tr><td>Auditory Icons</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Earcons</td><td colspan="2">✓</td><td colspan="2">✓</td><td colspan="2">✓</td></tr>
</table>

Table 5.1: Mapping between the important level of feedback types and non-speech sound used in Auditory Avatar Body Gestures Platform.

5.5.1 Feedback Types

There are six types of feedback that are communicated between users and interfaces. It is same that being used in the second experiment (see 4.5.1). The first type of feedback is about Error that tutor identifying where errors have been made (or where work is correct).

Second type is about Comment that tutors demonstrating techniques or procedures the student may not have used appropriately or correctly. Third type is about Engage Thinking which is engaging students in some thinking in relation to what they have written or presented. Fourth feedback type is about Explain Ideas that explaining ideas or concepts the student has not fully understood. Fifth type is about Further Suggestions which is suggesting further study or reading. Finally is about Mark that justifying marks or grades.

5.5.2 Using of Non-Speech Metaphors

Earcons used in this experiment were utilised to link the importance level of feedback types when spoken by the virtual tutor. These feedback types were classified in three groups in relations of its importance; high, medium and low. Each of these levels was represented by a rank as follows: 1 for low, 2 for medium and 3 for high. Due to the likely of implementing earcons to link details of mathematical characteristics, these musical technology metaphors have been used in experiment and three different single-meaning earcons were developed, each of which was devoted to connect, in easy and verbal structure, individual significance stage at a time. The style of these musical technology stimuli was depending on the suggestions for the generation of earcons [5.8, 5.9] where the speech of drum device was chosen to perform a different variety of notices to connect the necessary oral details. The first earcon was consisting of only one note to connect feedback low important level the second earcon contains two notices to indicate feedback medium important level.

However, in the last earcon, a series of three growing concept notices was used to connect feedback high important level. Also, these earcons were brief and easy to assist in the presentation of the provided oral concept [5.10] to communicate feedback types were the representation of these aspects by auditory icons could provide natural mapping to help the users to remember and interpret it accurately. As shown in Table 5.2, the sound of broken glasses communicated that Error (type of feedback) will start, and opening tab of bottle‖ sound communicated that this statement start about Comment (type of feedback). Also, the sound of beep‖ was used to indicate that Engage Thinking (type of feedback) start whereas Explain Ideas (type of feedback) was communicated by the sound of closing door. I addition, the sound of opening door linked that the Further Suggestion (type of feedback) will start and the Mark (type of feedback) is communicated through clapping sound. Both earcons and auditory icons were performed during the presentation in pause intervals so that it does not affect with the speech of the virtual tutor.

5.6 Experimental Design

The effect of using different types of feedback and usability of Avatar body gestures as e-feedback platform was tested in the second experiment reported in Chapter 4. Therefore, only one group of users was involved in this experiment to evaluate the

Feedback Type	Sound	Duration (seconds)
Error	Broken glasses	19
Comment	Opening tab of bottle	17
Engage Thinking	Beep	22
Explain Ideas	Closing door	14
Further Suggestions	Opening door	15
Mark	Clapping	21

Table 5.2: Auditory icons are used in Auditory Avatar Body Gestures Platform to indicate students that specific feedback type will start.

addition of non-speech auditory sound in Auditory Avatar Body Gestures Platform. Although different tasks were designed in this empirical investigation, it was believed that the obtained results could serve as a comparison point to explore if the addition of earcons and auditory icons in Auditory Avatar Body Gestures Platform resulted in enhancing the Avatar Body Gestures Platform in terms of usability and student's engagement. In total, 24 users participated in the experiment individually.

5.6.1 Instruments

A total of 24 users have taken part in the experiment individually. The procedure followed in performing the experiment with each user is following subsections.

5.6.1.1 Pre-experiment questionnaire

In this questionnaire, users will be asked to:

1. Provide personal and educational information.
2. Record previous knowledge about feedback and its types.

5.6.1.2 Demonstration of the experiment

The experimental platform was introduced by showing a one-minute video recording that describes the components integrated in the interface. Thereafter, six feedback types about the typical coursework written by a student were presented interactively using the experimental platform. These feedbacks were concern upon student coursework. Therefore, the order of presentation was the same for all users (i.e. feedback 1 then feedback 2 then feedback 3). In addition, a short training for 90 seconds was provided in which each user had the opportunity to listen to the implemented non-speech sounds. The aim of this training was to insure users' engagement to understand and interpret each of these sounds.

5.6.1.3 Post-conditional tasks

These tasks were required to be performed upon completion of feedback type and were aimed at evaluating the users' achievement of that platform used. Each user was asked to answer six questions related to the delivered feedback type. These questions were divided to feedback recall and recognition questions. Furthermore, the students' engagement test performs to test student's engagement with feedback types while linked by non-speech metaphors.

5.6.1.4 Post-experiment questionnaire

The user had to respond to the satisfaction questionnaire. More specifically, this questionnaire was composed of 10 statements each of which had a 5-point Likert scale where one denoted strongly disagree and five denoted strongly agree. Also, users were asked to express their views towards the use of earcons and auditory icons in terms of Irritation, Disappointment, Usefulness and Concentration.

5.6.2 Independent variables

1. Multimodal metaphors. In this experiment the earcon and auditory icons will be investigated with integration in avatar body gestures platform.
2. Feedback type. As mentioned in section (4.5.1) there are six different type of feedback. These feedback types (Error, Comments, Engage Thinking, Explain Ideas, Further Suggestions and Mark) are used as independent variables.
3. Feedback Recall and Recognition question. In each platform, questions type will be tested to state the influence on usability terms and Student's engagement.

5.6.3 Dependent variables

1. Achievement level (correct answers): This is the number of successfully completed tasks. It is measured by the correct answers to the recall and recognition questions relating to the communicated feedback.
2. Engagement of users with the type of feedback: This was measured by the number of users who correctly indicated these features after being communicated by the non-speech sound.
3. Interpretation of earcons and auditory icons: This was measured by the number of users who successfully interpreted the auditory stimuli in the context of being communicated in the experimental platform.
4. User satisfaction: This was measured by the responses of users to the post-experimental questionnaire.

5.7 Data Collection and User's Profile

The collection of experimental data was mainly based on two resources; observations and questionnaires. For example, users' answers to both pre and post experimental questionnaires helped in gathering the data needed to obtain an overall feedback about the characteristics of the users. Additionally, users' responses to the post-conditional tasks contributed to the evaluation of student's engagement and the usability parameters (i.e. achievement level and user satisfaction).

Figure 5.1 shows the profile of the sample. It shows level of education, experience with the use of computers, e-learning systems and contacting tutors online. Twenty four under-graduate and postgraduate users (64% males and 36% females) were recruited to investigate the experimental platform.

A post-experimental questionnaire was also completed by all users. The age of the sample consisted of 38% between 18-24, 56% between 25-39, and 6% between 40-49 years old. The users were 65% undergraduate and 35% postgraduate students. The analysis of the respondents found that 60% had used a computer for more than 15 hours; 25% had used a computer for between 8-14 hours was; and 15% had used a computer for 1-7 hours per week. The proportion of participants who used e-learning systems was 90%. The percentage of users who had contacted their tutor through a computer regarding feedback was 80% while 20% of participants did not contact their tutor through a computer. Approximately 95% of the users read the feedback that written or sent by their tutor while 5% do not read the feedback send to them. 80% of users faced some difficulty (either overloaded or did not understand) when they wanted to read the feedback (see Appendix C2).

5.8 Results

The obtained experimental results were analysed in terms of achievement level, engagement (in terms of correct and incorrect users' answers), users' views regarding the non-speech sounds that accompanied the avatar body gestures as tutor, and user satisfaction. Also, the levels of significance in users' responses was examined using the nonparametric Chi-square statistical test at $\alpha = 0.05$ indicating significant difference when p-value was found less than 0 .05.

5.8.1 Achievement Level

The number of correct and incorrect users' answers to the required feedback questions type was used to assess student's achievement level of Auditory Avatar Body Gestures Platform in presenting the feedback types.

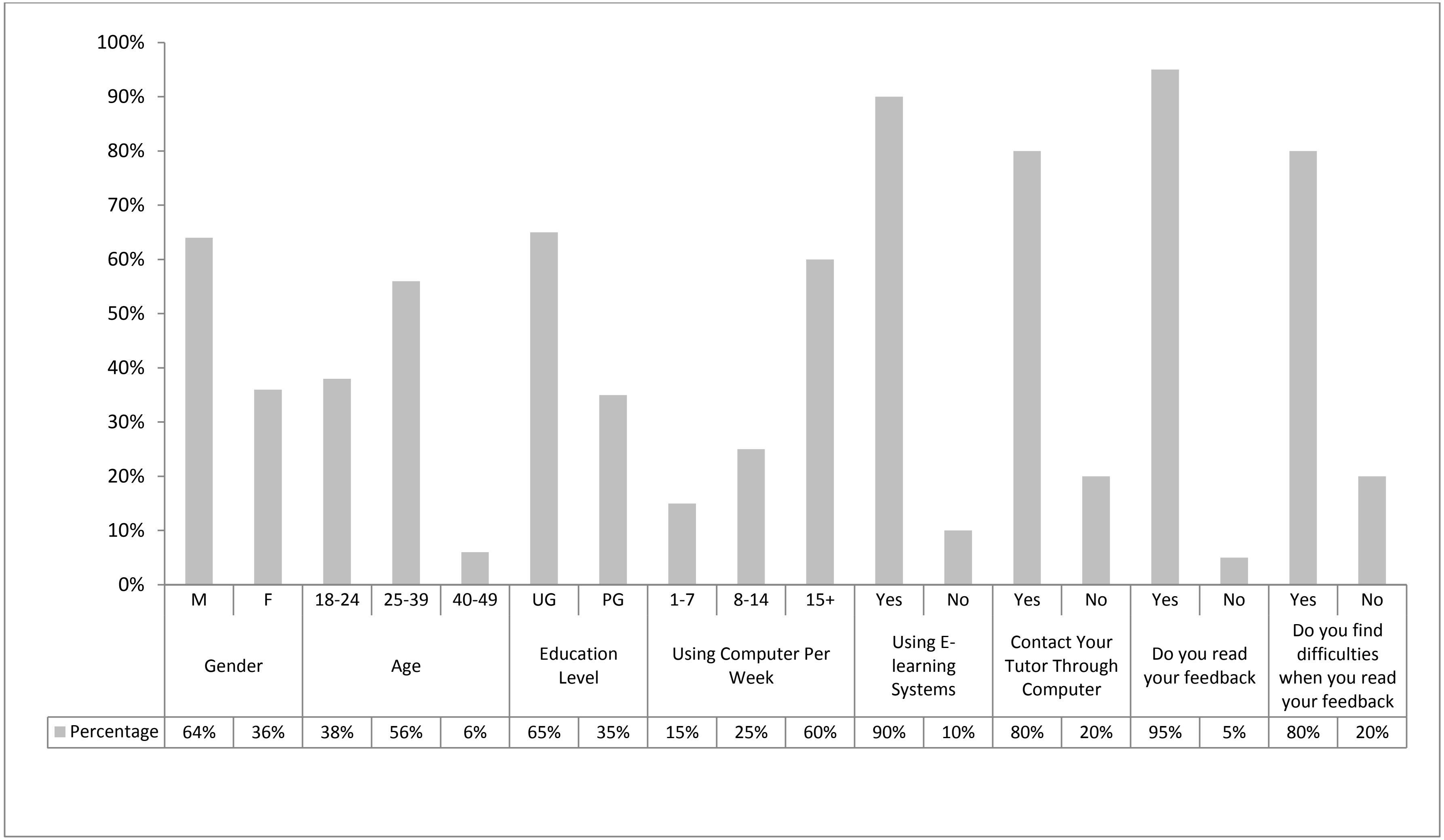


Figure 5.1: The user profile.

Each user was required to answer six questions based on feedback types of two feedback questions type; recall and recognition. Therefore, the total number of questions was 144 (24 user * 6 questions per user) equally distributed over the two types. Figure 5.2 shows the percentage of correct and incorrect answers achieved by users for all questions, grouped by feedback type and for feedback question types. Figure 5.2 shows that the overall percentage of correct answers was 74.3% compared to 25.7% for the incorrect.

In terms of answers, 107 out of 144 questions were correctly answered. These results were significant ($x^2(1)$ = 34.03, cv = 3.84, p < .05). In terms of feedback question type, Figure 5.2 shows that the percentage of successfully answered recall questions was higher than that for the recognition ones. In response to 72 questions in each type, the number of correct answers was 61 (84.7%) and 46 (63.9%) in recall and recognition questions respectively. Although users performed better in the recall tasks, the difference between correct and incorrect answers was found significant in both feedback question types recall ($x^2(1)$ = 34.7, cv = 3.84, p < .05) and recognition ($x^2(1)$ = 5.6, cv = 3.84, p < .05).

Figure 5.2 shows the correct answers attained by users for each question related to the feedback types delivered. The achievement of users was varied across these questions. More specifically, the percentage of users who correctly answered questions related to engage thinking and error categories was 91.7% (22 users) and 87.5% (21 users) respectively.

Variable	Chi-square value	Asymp. Sig.	Significance
All Feedback Questions	34.03	0.000	Yes
Feedback Type			
Error	13.5	0.000	Yes
Comment	0.167	0.683	No
Engage Thinking	16.7	0.000	Yes
Explain Ideas	4.2	0.041	Yes
Further Suggestions	6.0	0.014	Yes
Mark	2.7	0.102	No
Feedback Questions			
Recall	34.72	0.000	Yes
Recognition	5.6	0.000	Yes

Table 5.3: Chi-square values and significance levels relating to the acheivement level.

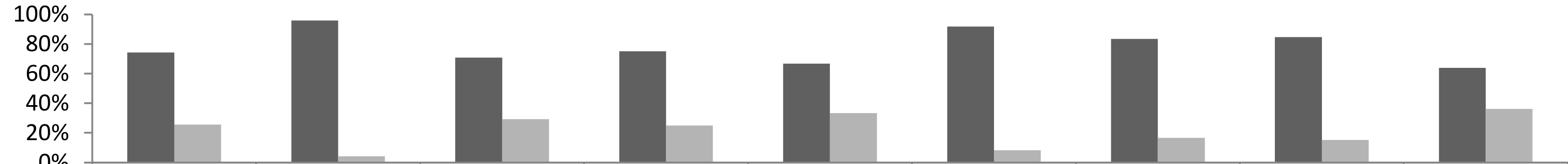
However, it seems that the remaining feedback questions type were more difficult to answer. The percentage of correct answers declined to 75% for further suggestion, 70.8% for explain ideas, 66.7% for mark and 54.2% for comment. Table 5.3 shows that the results were significant in terms of the difference between correct and incorrect answers for error, engage thinking, explain ideas and further suggestion whilst no significance has been obtained for comment and mark feedback types.

Figure 5.3 shows the number of correct answers provided by each student. It can be observed that two users (11 and 17) answered all questions successfully whereas another 8 users accomplished 5 correct answers.

To summarise, it can be said that the incorporation of well-known environmental sounds and short musical stimuli along with the virtual tutor was found to be beneficial in delivering the feedback content in e-feedback interfaces. In other words, using these auditory messages can complement the role of the virtual tutor and it is more likely to result in capturing the users' attention to key parts of the delivered learning content. As a result, it enhances significantly the achievement of users in terms of successfully responding to different evaluation questions. More details about the data to the feedback questions types can be found in Appendix C3.

Variables	**Chi-square value**	**Asymp. Sig.**	**Significance**
All Non-Speech Sound	71.2	0.000	Yes
Auditory Icons			
Error	20.2	0.000	Yes
Comment	4.2	0.041	Yes
Thinking	6.0	0.014	Yes
Explain Ideas	2.7	0.102	No
Further Suggestions	16.7	0.000	Yes
Mark	10.7	0.001	Yes
Earcons for Feedback (importance)			
High	13.5	0.000	Yes
Medium	4.2	0.041	Yes
Low	2.7	0.102	No

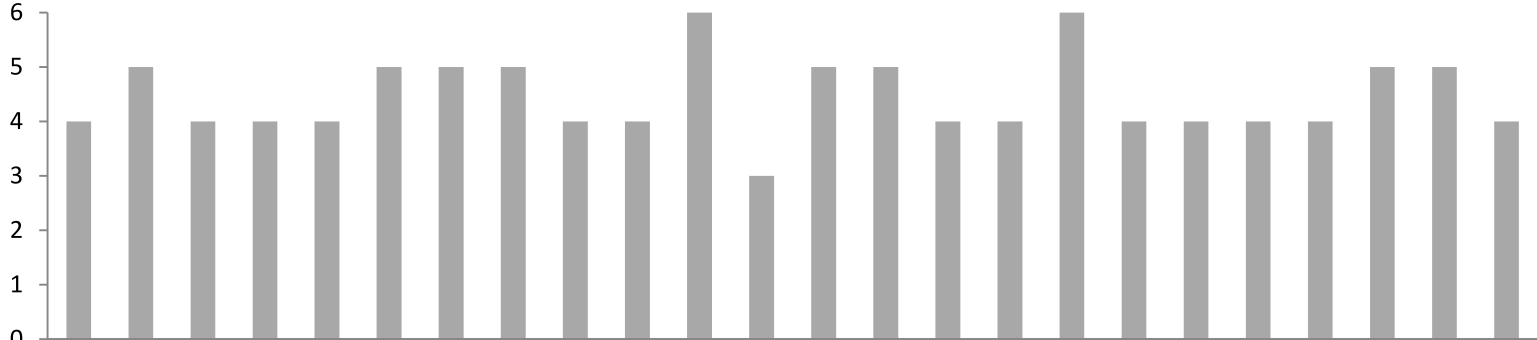
Table 5.4: Chi-square and significance levels relating to engagement test 1.



	All Questions	Feedback Types						Feedback Question Types	
		Error	Comment	Engage Thinking	Explain Ideas	Further Suggestion	Mark	Feedback Recall	Feedback Recognition
Correct	74.3%	95.8%	70.8%	75.0%	66.7%	91.7%	83.3%	84.7%	63.9%
Incorrect	25.7%	4.2%	29.2%	25.0%	33.3%	8.3%	16.7%	15.3%	36.1%

Correct Incorrect

Figure 5.2: Correct and incorrect percentages of answers achieved by users for all questions, feedback types and feedback question types.



	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17	U18	U19	U20	U21	U22	U23	U24
Achievement level	4	5	4	4	4	5	5	5	4	4	6	3	5	5	4	4	6	4	4	4	4	5	5	4

Figure 5.3: The number of correct answers provided by each user.

5.8.2 Engagement

Upon completion of the achievement tasks, users were asked to do two engagement tests. In the first one, students were presented with six different feedback types and they were requested to indicate the type of feedback that each of the incorporated non-speech sound communicated during the presentation of the feedback. In this regard, the total number of questions was 216 (24 user * 9 questions per user).

Figure 5.4 shows the correct responses of users to this task with regard to all non-speech sound, earcons and auditory icons. More details are presented in Appendix C4. Figure 4 shows that 81% (136 out of 168) of the feedback that was indicated as important as communicated by earcons and feedback types by auditory icons, were correctly recognised by users.

Statistically, this result was significant ($x^2(1) = 71.0$, cv = 3.84, $p < .05$). Also, Figure 5.4 demonstrates that most of users identified correctly the feedback types communicated by auditory icons. More specifically, 95.8% (23 users) recognised Error (Type of Feedback) by the sound of broken glasses correctly whereas 91.7% (22 students) accurately determined further suggestion (type of feedback) by the sound of an opening door and 83.3% (20 students) highlighted mark (type of feedback) by a clapping sound. This percentage dropped to 75% and until 66% for the remaining feedback types.

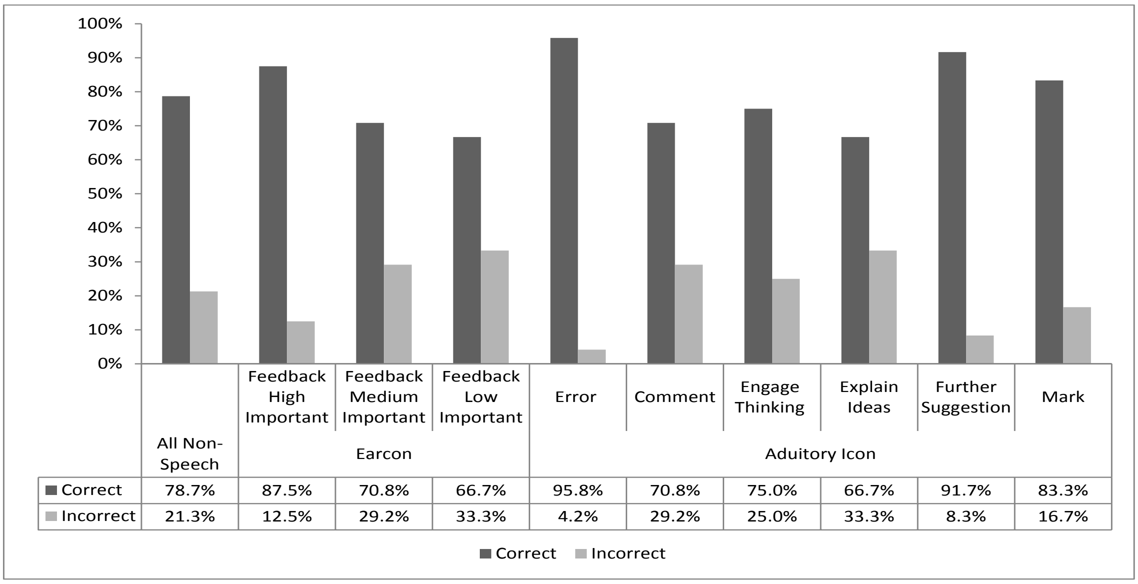


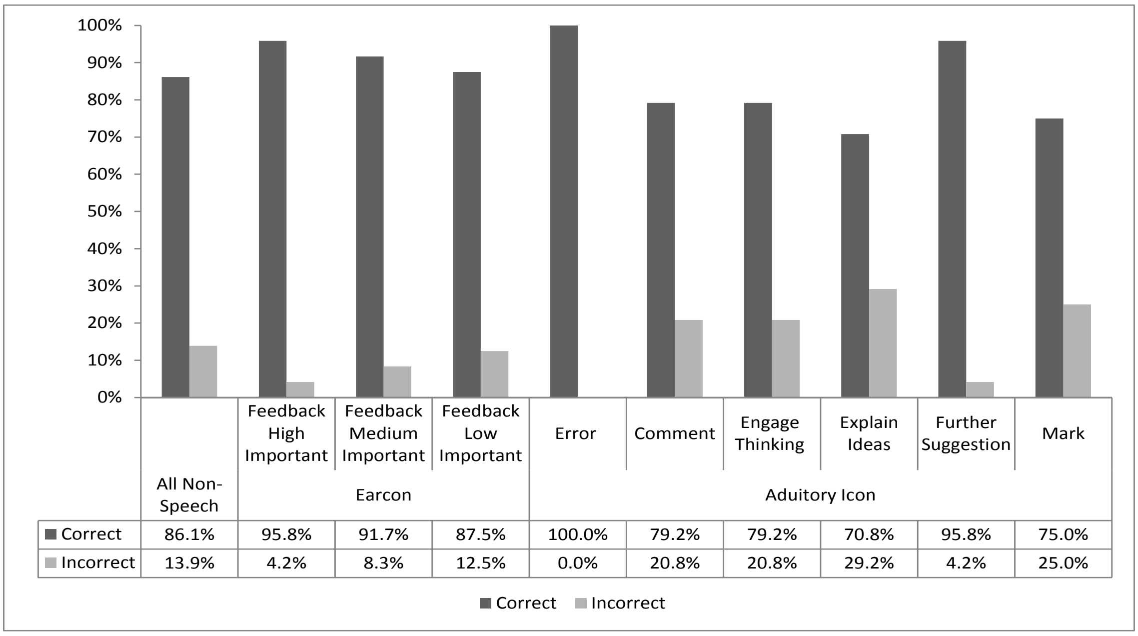
Figure 5.4: Correct recognition of users of the feedback types that were communicated by non-speech sounds for all sounds, earcons and auditory icons.

Variables	Chi-square value	Asymp. Sig.	Significance
All Non-Speech Sounds	112.7	0.000	Yes
Auditory Icon			
Error	4.2	0.041	Yes
Comment	8.2	0.004	Yes
Engage Thinking	8.2	0.004	Yes
Explain Ideas	4.2	0.041	Yes
Further Suggestions	20.2	0.000	Yes
Mark	6.0	0.014	Yes
Earcon for Feedback (Important)			
High	20.2	0.000	Yes
Medium	16.7	0.000	Yes
Low	13.5	0.000	Yes

Table 5.5: Chi-square and significance calculations relating to engagement test 2.

When students were requested to highpoint three words communicated by earcons as feedback important high, medium and low level, Figure 5.4 shows that 87.5% (20 users) responded correctly for feedback highly important compared to 70.8% (17 users) for feedback of medium importance and 66.8% (16 users) for feedback of low importance.

The Chi-square results (see Table 5.3) show shows that the engagement of users was significant given their correct answers as measured in the experiment. In the second engagement test, three sounds were played for each of the feedback types and the importance level of the feedback. Users had to distinguish the sound that communicated each of the feedback types and its level of importance.



	All Non-Speech	Feedback High Important (Earcon)	Feedback Medium Important (Earcon)	Feedback Low Important (Earcon)	Error (Aduitory Icon)	Comment (Aduitory Icon)	Engage Thinking (Aduitory Icon)	Explain Ideas (Aduitory Icon)	Further Suggestion (Aduitory Icon)	Mark (Aduitory Icon)
Correct	86.1%	95.8%	91.7%	87.5%	100.0%	79.2%	79.2%	70.8%	95.8%	75.0%
Incorrect	13.9%	4.2%	8.3%	12.5%	0.0%	20.8%	20.8%	29.2%	4.2%	25.0%

Figure 5.5: Recognition of users for all the tested non-speech sound.

The obtained results can be seen in Figure 5.5 for all non-speech sounds, earcons and auditory icons. On the whole, 86.1% of the tested sounds were correctly recognised by students. This result was highly significant ($x^2(1)$ = 112.7, cv = 3.84, p < .05, see also Table 5.5). Figure 5.5 shows that 100% (24 students) correctly recognised the auditory icons broken glasses for error and 95.8% (23 students) opening door for further suggestion. However, this percentage was between 79% and 75% for the other sounds that communicated the rest of the feedback types. With respect to earcons, Figure 5.5 shows that the sounds used for high, medium and low importance of feedback were correctly recognised by all users significantly. The Chi-square results, as shown in Table 5.3 demonstrated significant difference between correct and incorrect recognition for all the tested sounds. In brief, the obtained results suggest that the tested auditory icons and earcons could be successfully interpreted and easily remembered by students when utilised in e-feedback interfaces to signal the importance of specific content delivered by a virtual tutor.

5.8.3 User Evaluation

Subsequent to the experiment, users were requested to express their views (agreement or disagreement) in terms of irritation, disappointment, usefulness and concentration towards the use of earcons and auditory icons that enhanced the voice of the virtual tutor.

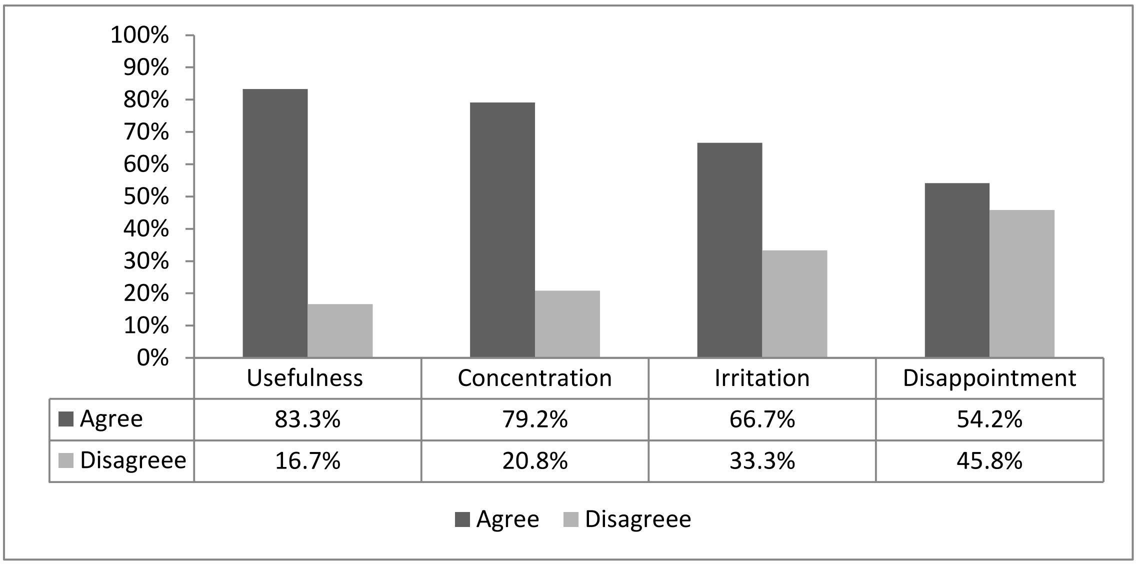


Figure 5.6: Results of the user evaluation toward the non-speech sound.

The responses of users are shown in Figure 5.6. It can be seen that users' views were positive when earcons and auditory icons were used interactively in the Auditory Avatar Body Gestures Platform. About 66.6% of the students felt irritated when they heard the sounds during the experiment. It is noticeable that there was no large difference in disappointment. The percentage of users who felt disappointment when earcons and auditory icon were presented in the interface was about 54.2% and 45.8% for whose disagree. In terms of usefulness, 88% of users found these sounds helpful. Furthermore, 79.2% of users felt that the presentation of sound helped them to focus during the interaction with the Auditory Avatar Body Gestures Platform.

5.8.4 Satisfaction

Users were also required to answer a satisfaction questionnaire composed of 10 statements each of which had a 5-point Likert scale. The first 10 statements were adopted from SUS questionnaire [5.11] to obtain users' attitude towards the different aspects of the Auditory Avatar Body Gestures Platform. On average, user satisfaction score calculated using the SUS approach was 82.4% indicating a high positive attitude. The percentage of students' responses to each statement in the satisfaction questionnaire is illustrated in Figure 5.7. The positive statements (S1, S3, S5, S7, and S9) in SUS questionnaire attained high levels of users' agreement (between 91.7% and 81.3%). More specifically, 85.4% of the students agreed that the system was well integrated of

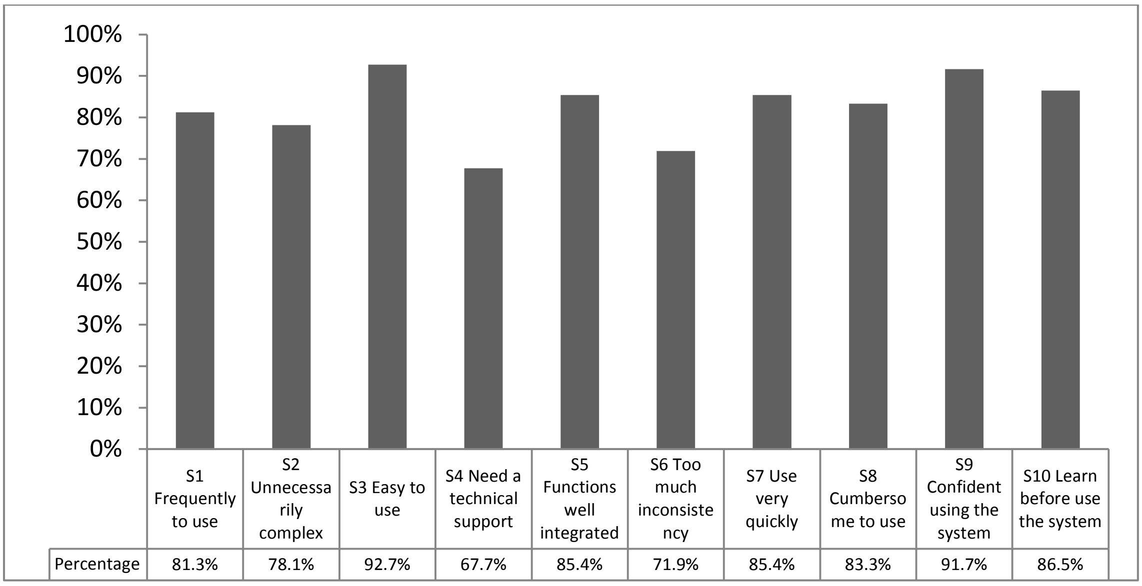


Figure 5.7: The percentage of user responses to each statement in the satisfaction questionnaire.

functions (S5) and that most people well learn how to use it very quickly (S7). The percentage of users who felt confident (S9) during the interaction with Auditory Avatar Body Gestures Platform was 91.7%. However, this percentage was 81.3% and 92.7% for frequently to use (S1) and ease of use (S3) respectively. On the other hand, users' disagreement regarding the negative statements (S2, S4, S6, S8, and S10) was observed high and fluctuated between 67.7% and 85.6%. According to most of the users (86%), students need to learn before use the system (S2) nor cumbersome to use (S8). However, a slightly lower percentage of them (67.7%) did not agree that using the tested interface requires the need for technical support (S4).

5.9 Discussion

During the experiment, it was observed that the students were concentrated on the delivered feedback content. The reason could be attributed to the inclusion of interaction metaphors of different modalities in the tested interface. The textual metaphors combined in the presentation part of the interface along with body gestures of the virtual tutor contributed to capturing user‘s visual attention towards the presented information. At the same time, further auditory explanations about this information were provided by the voice of the virtual tutor. What is more important, using the non-speech sounds provided students with a mechanism to realise when important feedback level is about to be presented and when it has been delivered. Also, it helped them to determine the feedback types in the feedback content. The obtained result showed that these sounds did not irritate, disappoint or distract the users as they found it useful (see Figure 5.6). Also, users were able to engage with the feedback content which was communicated by these sounds (see Figure 5.4 and 5.5). Therefore, when users were asked about the presented feedback types, they were able to provide the correct answer as shown in Figure 5.2. As a result, they were satisfied with the tested e-feedback interface. The first experimental hypothesis (H1) examined the effect of the added non-speech sounds on users' achievement level. Findings of this experiment demonstrated that users' achievement level was significantly aided by the addition of earcons and auditory icon and assisted in extending the contribution of body animated virtual tutor to realise both types of the required evaluation activities, feedback types and recall and recognition.

However, the contribution of these non-speech sounds was varied across the required feedback questions. For example, auditory icons significantly helped users' achievement level in both feedback recall and recognition questions where the required details to answer these questions were attached with well known sounds from every day life. On the other hand, earcons contributed particularly in recall questions much more than in recognition ones. In other words, the earcons used in this experiment were less beneficial compared to auditory icons. Nevertheless, the results on overall users' achievement level were significant in both recall and recognition activities supporting what have been hypothesised in H1.

The results of the experiment indicated that the users were satisfied, to a large extent with the inclusion of auditory icon and earcons in the evaluated e-feedback interface (see Figure 5.6). The majority of students stated that these sounds were neither irritating nor disappointment, helped their engagement and did not divert their concentration away. Also, the used auditory icons were selected to help in making a natural mapping between the feedback content types and known sounds from the surrounding environment. Furthermore, each of these sounds conveyed only one meaning at a time and used consistently throughout the Auditory Avatar Body Gestures Platform. These aspects are important particularly when they are incorporated in parallel with other auditory and visual metaphors (see 5.12, 5.13 and 5.14). These aspects, in addition, led to generate positive users' feelings with respect to the tested e-feedback interface. These results supported all the assumptions made by the experimental hypotheses H2, H3 and H4. On the whole, the obtained results suggest that utilising non-speech sound alongside body gestures of speaking virtual tutors in the form of avatars enhances significantly the usability and engages users with the delivery of e-feedback.

5.10 Conclusion

The experiment described in this Chapter investigated the achievement level and user engagement with earcons and auditory icons when used as complementary auditory signals to indicate the different feedback types as presented by a virtual tutor. The experiment also investigated users' satisfaction. A total of 24 users have taken part in the experiment to evaluate the experimental e-feedback interface that extended the one tested in the previous experiment by the addition of Non-Speech sounds. The obtained results demonstrated the effectiveness of these sounds to capture users' attention to important parts of the feedback, and contributed positively to enhance students' achievement level in different learning activities. Additionally, these sounds were easily remembered, understood, and was satisfactory to users. Therefore, the use of these metaphors was found to be significantly helpful to enhance the usability of an e-feedback interface.

Finally this Chapter investigated the addition of auditory non-speech metaphors to an Avatar Body Gestures Platform in terms of user engagement with different types of feedback and questions. Three types of multimodal interaction metaphors were incorporated in this platform: visual-only metaphors (text which is feedback type content), audio-visual metaphors (speaking avatar with body gestures) and auditory ones (earcons and auditory icons). The collection of experimental data was mainly based on two resources; observations and questionnaires, also on users' responses to the post-conditional tasks contributed to the evaluation of student's engagement and the usability parameters (i.e. achievement level and user satisfaction).

The results of the experiment indicated that the users were satisfied, to a large extent with the inclusion of auditory icon and earcons in the evaluated e-feedback interface. The majority of users stated that these sounds were neither irritating nor disappointment, helped their engagement and did not divert their concentration away. Also, the used auditory icons were selected to help in making natural mapping between the feedback content types and known sounds from the surrounding environment. Furthermore, each of these sounds conveyed only one meaning at a time and used consistently throughout the Auditory Avatar Body Gestures Platform. These aspects are important particularly when it is incorporated in parallel with other auditory and visual metaphors. These aspects, in addition, led to generate positive users' feelings with respect to the tested e-feedback interface. These results supported all the assumptions made by the experimental hypotheses H2, H3 and H4. On the whole, the obtained results suggest that utilising non-speech sounds alongside body gestures of speaking virtual tutor could be useful in enhancing the usability and student's engagement in e-feedback interfaces.

Chapter 6

Conclusion

6.1 Introduction

This Chapter discusses the conclusions of the thesis with regard to the role of multimodal designs introduced in order to determine the usability and engagement of users with e-feedback interfaces. It also presents a summary of the derived results and the limits within which they are derived. Furthermore, the role of multimodal metaphors in interface of e-feedback applications is described on the basis of a set of empirically derived guidelines.

6.2 Review of the Experimental Work

The conducted research aimed to investigate the usability of specific combinations of multimodal metaphors to communicate different types of e-feedback in terms of efficiency, effectiveness, engagement and user satisfaction. The research consisted of three experiments.

The first experiment assessed the usability of designs that incorporated text, natural recorded speech, and facially expressive speaking avatars. Two experimental platforms were designed for the experiment. The first platform (VFI) communicated three types of feedback using text. The second platform (MMFI) communicated the same type of feedback using a multimodal design based on text, natural recorded speech, and a facially expressive avatar as a virtual tutor. Two independent groups evaluated the platforms by performing recognition and recall tasks that their difficulty increased progressively. Efficiency was measured by the time spent by each user to answer questions and complete tasks. The correct answers of the users were used to measure effectiveness and student engagement. User satisfaction was measured by post-experimental questionnaires (see Chapter 3).

The focus of the was to second experiment was investigate the role of the avatars to improve the usability and learning performance of the users with six types about feedback. One of the experimental interfaces deployed a single facially expressive face to face “video” with a single talking head while the other used additional body animation.

The third experiment dealt with synthesised speech for the sake of presenting the feedback. The aim was determining the opinions of the users when the virtual tutors use a particular set of facial expressions and body gestures in the interactive e-feedback context. The empirical testing of the interfaces used in experimentation was carried out by a group consisting of 36 members with a single user capable of evaluating 4 facial and 4 body gestures in total used in the experiments either positively or negatively. The factors deployed to measure the usability and student engagement had similarity to those used in the first experiment. (see Chapter 4).

The analysis of the extent to which the users are satisfied and the achievement level, student egagement of the non-speech sounds; earcons and auditory icons, was the subject of the third experiment with the aim of knowing the key aspects of the feedback contents presented by a single virtual tutor in the presence of body gestures. Furthermore, it also aimed to know the opinions of the users about the non-speech sounds. The experimental set up had almost similarity with second experiment except for the use of the earcons and auditory icons. A number of pre-introduced sounds were presented to a group of 24 users to know their understanding. Every user was responsible for answering 6 recall and recognition questions and had to remember the tested sounds in order to know the usage of these sounds during the interaction process. Furthermore, the users were allowed for expressing their attitudes to the assessed performance based on e-feedback (see Chapter 5).

6.3 Main Conclusions

This section addresses the conclusions and limitations of the experimental results in this thesis. The first experiment demonstrated the fact that the usability of the experimental platform with the multimodal metaphors was greater than the platform with text and graphics in presenting e-feedback to users. Combining text, natural recorded speech, and facially expressive avatars had greater efficiency in terms of reducing the time required to answer the engagement questions. They also were helpful in enabling the users to respond correctly to a greater number of questions, specifically if they were of higher complexity. In addition, the percentage of the users using the multimodal e-feedback interface was greater compared to the users using the text with graphics platform. This experiment however measured the total contribution of the multimodal metaphors and the combined effect in terms of usability and the user engagement. In this connection, the design of the second experiment was necessary to assess the individual role of avatars with particular facial expressions and body gestures as virtual tutors in e-feedback interfaces.

The second experiment with the facially expressive avatars and body animations showed greater efficiency, effectiveness, and user satisfaction compared to using face to face or synthesised speech. In addition, it was found to be empirically preferable to combine the body animated virtual tutor and the presented feedback material in one interface. In addition, the second experiment determined the best and worst facial expressions and body gestures in the assessed e-feedback environment. The derived results indicated that in the e-feedback interfaces, the role played by the body animated virtual tutor restricted learning activities associated with recall and contributed minimally to the recognition activities.

The results of the third experiment showed that combining earcons and auditory icons attracts user attention to the communicated feedback. The combination and synchronisation of the voice with the body gestures in the virtual tutor helped users to engage better with the various types of activities related to feedback. Finally, the obtained results demonstrated that users detected, comprehended, and interpreted feedback better with the aid of non-speech sounds.

6.4 Empirically Derived Guidelines

The obtained results of the experimentation carried out in this research were explained and described in terms of usability aspects of the e-feedback interfaces. The empirically derived results can also be interpreted in terms of design guidelines in order to inform and enhance the design and usability of e-feedback interfaces. The parameters used to evaluate usability included correct answers, time performance, and user satisfaction. These parameters were used to determine the success criteria (see Chapter 1). The experimental data indicated an 81-94% of the correct answers of users occurred when the e-feedback presentation involved positive facial with body gestures. This is a significant improvement to the 63-72% achieved when negative facial expressions were used. Also, interfaces deploying positive facial expressions and body gestures enabled users to perform tasks faster. Furthermore, users were more satisfied from multimodal interfaces than with the textual interfaces and, particularly, facial expression and body gestures were the most preferred and best rated by users. The e-feedback developers may take into account the guidelines described here for future design of e-feedback systems. The derived guidelines are dependent on length of text, speech metaphors, facial expressions, body gestures, and the fusion of facial expressions and body gestures.

6.4.1 Natural Recoded versus Synthesised Speech

This research designed virtual tutors (ie. avatars) with natural recorded speech. The use of natural recorded was preferred by most users as the communicated verbal messages were clear and understandable to users. These results are in agreement with other reported results in the literature that recorded natural speech is better than synthesised speech. The research in this thesis suggests that combining *tones* and *pitches* to stress particular words and phrases within the delivered speech is aiding user comprehension. The designer must exercise care to the synchronisation issues of spoken message, facial expression and body gesture.

The use of natural recorded speech also prevented the switch of the user's attention particularly in situations where the users are also presented with graphics in addition to the auditory messages. This, in turn, enables users to engage better with the presented material and was observed to require less effort in the memory of users. There is also evidence in other experiments in the literature that also support this finding [77]. The natural recorded speech can be altered, modified, and processed according to the requirements of the presentation and to deliver more and more content in a meaningful manner (i.e. the user can easily interpret its content). Natural speech can also be recorded from the tutor and then asynchronously presented as part of the e-feedback.

The research in this thesis suggests that synthesised speech should only be used for short messages to communicate e-feedback. For example, to give instructions to users and even in this case it should be in very short sentences. The result were not significant (see Table 4.2) for most voice expression used in our experimental platforms. Sequence of tone was also rated negative by 64% of the sample. The results of the other voice expressions were also similar. Approximately, 40% of the user sample found that voice tone, sequence of tone and emphasis on tone did not aid user understanding and engagement when used as part of a synthesised speech message. Therefore the extensive issue of these parameters in synthesised speech is not recommended.

6.4.2 Substituting Face-to-Face Communication with recorded Video

The result demonstrated that positive expressions such as *neutral*, *happy*, and *thinking* were significant. The unhappy or negative expressions were not significant. The use of a a recorded talking head with facial expressions in an interface component different from that used to present the textual feedback (as applied in avatar body gestures platform) did not appeal users as much as the facially expressive avatar with body gestures.

The comparison between face to face and avatar body gestures platforms revealed that usability levels were equivalent. However, it was significant in general. Even though, using avatar body gestures performed better than using face to face and their usefulness was rated higher. It is therefore suggested to use face to face (video) to deliver Mark and Comment feedback type.

6.4.3 Facial Expressions

In the second experiment, research was carried out to obtain an overall user viewpoint of the 4 facial expressions which were rated as the best choices in the interactive e-feedback environment. Despite of the low rating received from the users, there is a need for the *neutral* and *thinking* expressions to be used in e-feedback interfaces. For instance, they were observed to be useful in changing the flow of the presentation in a way that enables users to think, reflect and meaningfully interpret the communicated feedback. Therefore, on the basis of the empirical data, it is suggested to use facial expression to animate avatars particularly when *further suggestions* and *engage thinking* feedback types are communicated.

Furthermore, users of the MMFI in the experimental group were able to maintain their visual attention to the feedback content while they were listening to the auditory messages delivered by the speaking avatar. The inclusion of avatar's facial expressions in the electronic feedback interface aided users to focus better on the presented auditory stimuli while at the same time users were receiving information via the visual channel. Experimental data demonstrates that users were significantly aided by the addition of facial expressions (as part of an avatar) in the MMFI in terms of spending less time to successfully answer questions and complete tasks than their counterpart users in the VFI group. These results therefore suggest that the use of speaking facially expressive avatars will enable users to be more efficient than using text with graphic only metaphors in presenting clarifications on the feedback message.

The empirical results also showed a gradual growing contribution of the facially expressive avatars in the efficiency of users as the MMFI group responded significantly faster to the required easy, moderate and complex evaluation questions. There was also empirical evidence to suggest that the efficiency of users using the facially expressive avatar was additionally influenced by the complexity level of the communicated feedback content.

6.4.4 Body Gestures

Positive body gestures should be included in the design of an expressive avatar that communicates feedback and it was found to be particularly useful when error, further suggestion and mark need to be communicated.

The user's review was also assessed by the second experiment by making use of 4 body gestures used by the virtual tutor to present the feedback materials in the e-feedback environment. The obtained results showed that the gestures (e.g. pointing, walking and arms folded) used contributed to the learning process and engaged the users with the different types of the communicated feedback. However, there were some body gestures (e.g. chin stroking and hands clenching) that according to data and observations are less likely to have contributed to the comprehension and engagement of users with the feedback communicated by the virtual tutors. Users also did not find these gestures particularly helpful. The remaining positive gestures demonstrated significant positive ratings (see Table 4.3). Users felt that these body animations attracted their attention with the types of feedback presented and that was the closest simulation to a real face-to-face interaction with a tutor. Furthermore, users' opinions showed that most body gestures such as *arm pointing* and *hand clenching –front should* be used by the lecturers as these gestures were significantly positively perceived.

6.4.5 Integration of Virtual Tutor in E-feedback Interfaces

The second experiment conducted indicated that it is necessary to combine the body animation of the virtual tutor as constituents of the same interface in an e-feedback environment. The maximization of the body gestures in the e-feedback interfaces (pointing) can be achieved when the feedback contents (textual, graphical or both) are placed beside the virtual tutor with the body animation using the same scene in the same manner as was deployed in the case of avatar with body gestures in the e-feedback interfaces. This strategy is more useful specifically when it is desired to focus the attention of the learners to the presented information. The textual metaphors combined with body gestures of the virtual tutor contributed to capturing user‘s visual attention towards the presented information. At the same time, further auditory explanations about this information were provided by the voice of the virtual tutor.

Also, this technique enables users to locate the various sources of the delivered content to the area of their visual focus and thus preventing the switching their visual attention to other parts of the interface. Therefore, the guideline for designers is to produce a design that facilitates users to focus their visual and auditory attention in one area within the interface and minimise any occasions that users are encouraged to switch their attention from one part of the interface to another. Users will be more engaged when they focus predominantly in one location and efficiency and effectiveness of users are more likely to be decreased when their visual attention is scattered or frequently switching. It has been observed that when users were searching for the delivered information, a memory overload and a reduction of the learning efficiency occurred. This finding builds upon other experiments that highlighted the scope of the fusing a varied set of information components into a single place in the interface [74].

6.4.6 Non-speech Stimuli

The combination of speech and non-speech stimuli was found to be helpful in communicating e-feedback. The use of non-speech stimuli provided users with an *announcing and ending mechanism* of the delivery of important feedback. Also, it helped users to disambiguate the types and content of the feedback. The empirical results and experimental observations showed that the speech and non-speech stimuli did not irritate or distract the users. Users were observed to engage with the feedback content when the feedback was presented in the presence of non-speech stimuli. Therefore, when users were asked about the presented feedback types, they were able to provide the correct answer. As a result, they were satisfied with the approach taken by the experimental interface. As indicated by the results obtained from the third experiment, earcons and auditory icons can also be deployed to strengthen the role of the body animated virtual tutor and enabled users to meaningfully interpret the feedback without confusion or ambiguity. For instance, auditory icons (e.g. door opening) can inform users that an important statement is about to be communicated and similarly other auditory icons (e.g. door closing) can signal the end of the statement. In addition, earcons can be used to highlight or annotate parts of feedback or statements. Auditory stimuli in this context needs to be used as a aid to disambiguate and attract the attention of users at specific parts of the communicated feedback. Designers preferably should insert these tones within the pause intervals of the pause intervals of the spoken messages by the virtual tutors in a way that does not interfere with the spoken message. In this manner, it is more likely that users will identify the critical parts of the feedback, increase attention and meaningfully interpret the feedback in its most critical parts.

Auditory icons also significantly helped users to achieve better in both recall and recognition questions where the required answer to these questions was communicated by auditory icons only. On the other hand, earcons contributed particularly in recall questions much more than in recognition ones. In other words, the earcons used in this experiment were less beneficial compared to auditory icons in this particular context.

6.4.7 Complexity and Type of Feedback

The first experiment also demonstrated that suitable combination of text, natural recorded speech, and avatars produces a design that is capable to significantly enhance the performance of users in moderate to difficult tasks for both recall and recognition questions. The virtual tutor with body animation will enable users to be more efficient and effective in recall actions compared to the recognition activities. It was also found that the use of non-speech stimuli significantly enhanced the understanding of the communicated feedback by the virtual tutors. In essence, the multimodal interaction metaphors as evaluated and presented in this thesis are more likely to make a significant contribution in e-feedback interfaces that communicate a more complex feedback that extensively involves memory recall and recognition processes to meaningfully interpret the communicated feedback. The empirical data in this thesis suggests that the contribution of multimodal metaphors to simple straight forward feedback (e.g. a mark, a statement of less than 10 or so words) was minimal as observed with some the simple tasks in our experiments.

6.5 Future Work

6.5.1 Additional Facial Expressions and Body Gestures

The second experiment in this research investigated 4 facial expressions and 4 body gestures when used by the virtual tutor to communicate the various types of feedback. Further experiments are needed to examine additional facial expressions and body gestures. The best and least performing facial expressions and gestures will benefit by further evaluation. The expected outcomes could contribute in producing wider and broader guidelines for the use of facial expressions and body gestures in e-feedback interfaces.

6.5.2 Smart Virtual Tutor

The virtual tutors investigated throughout this thesis were successfully used to communicate e-feedback in this thesis. The users in the second and third experiment highlighted the need to ask questions and receive immediate answers by the virtual tutors. These features will need intelligent content being build into the system relating to the context of feedback. Therefore, a more interactive 'dialogue' process with the virtual tutor will be desirable both in terms of the research challenges involved as well as of the benefits in terms of usability and user engagement. For example, speech recognition technology can be involved to enable orally-directed queries by users. In this case, the virtual tutor could have intelligent capabilities such as retrieval of the required explanations and automatic generation of relevant verbal and non-verbal responses.

6.5.3 Personalised Virtual Tutor

Except for the expressions of the face and body, the thesis does not take into account the effects exhibited by the external properties of the virtual tutors such as gender, voice, ethnicity, and age. The performance of the user may be affected by these factors. Further research in this direction by accommodating different learning styles and tailored learning will also be beneficial. For instance, virtual tutors can be personalised to accommodate specific user needs.

6.5.4 Virtual Tutors for Less-able Users

Another direction that merits further investigation is the use of the virtual tutor for users with specific learning disabilities. For example, the use of sign language for deaf and mute users. A varied set of the body gestures can be programmed on the basis of demands so as to demonstrate the components of the language. Exploration of other advanced techniques such as capturing body gestures and automatically generating the virtual tutor's body animation could also be accomplished with further research.

6.5.5 Comparison of Personalisation for Different User Groups

The user samples used in this thesis was predominantly homogeneous. However, an e-feedback presentation that adapts to specific user needs is likely not be uniform. Therefore, there is a need to research and understand the greater diversity of users from different backgrounds and academic domains. For instance, users samples can be drawn from humanities, health and life sciences or purely sciences background.

6.5.6 Other Feedback Types

The main types of feedback investigated in this thesis included error, comments, and marks as well as other types. However, further research with different types of feedback in relation to the user learning needs and specialised context would benefit the development of further 'know-how' knowledge in communicating e-feedback in specialised context situations.

6.5.7 Mobile e-Feedback

All experiments in this thesis were performed using a desktop environment. However, portable mobile computing is increasingly becoming main stream for learning and interaction. The way that the multimodal designs can be ported on smaller screens (eg. 4 to 5 inch) requires investigation due to the limited display area and user interaction model.

6.6 Epilogue

The conducted research in this thesis evaluated specific designs of multimodal metaphors to communicate e-feedback in interfaces in terms of usability and engagement of the users during their presentation by the virtual tutors. The three experiments conducted indicated that the usability and performance of the users to engage are greatly enhanced when earcons, auditory icons, natural recorded speech, and avatars with facial expressions and body gestures were used to communicate learning material in the e-feedback interfaces. The results obtained from the experiments and the empirically derived guidelines for the development e-feedback interfaces contribute significantly to the research literature and provide guidelines for developers and software designers. However, there is a need for further research to be conducted to investigate the contribution of multimodal metaphors over longer periods of learning in the context of mixed or distance learning.

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Appendix A – Experimental Stage 1: An investigation into the role of multimodal metaphors in an E-feedback interface.

A.1.1: Experimental Group.

I am pleased to present myself to you as one of the postgraduate research students in the Faculty of Technology at the De Montfort University. I am currently investigating the use of multimodal metaphors in e-learning interfaces, and I would like to obtain your views regarding the use of such multimodal metaphors such as: text/graphic, recorded speech, and avatar with facial expressions.

Please complete the following procedure:

- ❖ Answer the pre-experiment questions.
- ❖ Read each task.
- ❖ Perform the tasks and answer the required related questions.
- ❖ Then answer recall questions.
- ❖ After that, answer the satisfaction questionnaire.

Please complete all the requirements as honestly as possible. It would be grateful if you could fill in the following questionnaire sincerely and express your views. Your privacy is guaranteed as you will not be mentioned in any part of the study. Thank you very much, and I highly appreciate your contribution.

Pre-experiment Questions:

- **General Information: (tick one please)**

1- Age:
  - o 18-24.
  - o 25-39.
  - o 40-49.

2- Gender:
  - o Male.
  - o Female.

3- Education level:
  - o Undergraduate.
  - o Postgraduate.
  - o Other. ....

- **Using Computer: (tick one please)**

1- How often do use the computer per week?
   - 1-7 (hours)
   - 8-14 (hours)
   - More than 15(hours)
   - Never.

2- Do you use any kind of E-learning system?
   - Yes
   - No

3- Do you contact your tutor through computer?
   - Yes
   - No

Tasks:

This software is used to see a feedback from your teacher. After logging in to the programme you will see your modules on top bar. To get your feedback, you need to press on a module, then choose tasks, then press on feedback. In front of you now the essay that you have submitted to your tutor. There are seven buttons; each one presents a feedback that given by your tutor. By pressing any button some words or sentences will be highlighted and on left side may be some text or/and voice will be provided and on right side the avatar will appear. There are three tasks which you will go through to accomplish it. All tasks are classified on its level.

- ***Task 1:***

To complete this task you need to perform the following steps.

1. Click on ***"Error"*** button.

2. How many ***error*** have you seen. (choose one)
   - 20
   - 15
   - 14
   - 16

3. Click on ***"Corrections"*** button.

4. Move the cursor on "**Children have**", what is the ***correction***.
   ....

5. Click on ***"Comments"*** button.

6. Move the cursor on the first highlighted sentence. Then press on Avatar button on left side. Is the ***comment*** negative or positive? (choose one)
   - Positive
   - Negative

❖ ***Task 2:***

To complete this task you need to perform the following steps.

1. Click on ***"Explain Ideas"*** button.

2. Move the cursor on the second highlighted sentence. Then press on play button on left side. What did the tutor say? (choose one)

   - Errors in sentences grammar.
   - Discussed on the design.

3. Click on ***"Engage Thinking"*** button.

4. Move the cursor on the last highlighted sentence. Then press on Avatar button on left side. What did the tutor mention to? (choose one)
   - Expanding the conclusion.
   - Giving the reader simplest solutions.
   - Problems.

5. Click on ***"Suggestions Further"*** button.

6. Move the cursor on the third highlighted sentence. Then press on play button on left side. What did the tutor suggest?
   ....
   ....

7. Click on ***"Mark"*** button.

8. How much do you get? (choose one)
    - 68
    - 74
    - 71
    - 69

- ***Task 3:***

To complete this task you need to perform the following steps.

1. Click on ***"Error"*** button.
2. How many ***errors*** in the third paragraph. (choose one)
    - 5
    - 3
    - 1
3. Click on ***"Corrections"*** button.

4. What is the ***correction*** of "**board**", "**area**" and "**healthy**".
    "**board**" ....
    "**area**" ....
    "**healthy**" ....

5. Click on ***"Comments"*** button.

6. Move the cursor on the second highlighted sentence. Then press on play button on left side. To which the tutor ***comments*** on? (choose one)

    - Errors in sentences, grammar.....
    - Revisit class hand out.....

    Click on ***"Explain Ideas"*** button.

7. Move the cursor on each highlighted sentences. Then press on Avatar button on left side. In which sentences, did the tutor mention to "**You did not discuss the design, you focussed on the effects**" (choose one)
    - First highlighted.
    - Second highlighted.
    - Third highlighted.
    - Fourth highlighted.

- ***Task 4:***

To complete this task you need to perform the following steps.

1. Click on ***"Engage Thinking"*** button.

2. Move the cursor on the first highlighted sentence. Then press on Play button on left side. The tutor ***engaged student thinking*** on "**This problem33??**" (choose one)
    - o True
    - o False

3. Click on ***"Suggestions Further"*** button.

4. Move the cursor on the third highlighted sentence. Then press on Avatar button on left side. Did the tutor ***suggest*** rewriting some sentences? (choose one)
    - o Yes
    - o No

5. Click on ***"Mark"*** button.

6. How much do you get on the last paragraph? (choose one)
    - o 8/10
    - o 7/10
    - o 6/10
    - o 10/10

❖ ***Task 5:***

To complete this task you need to perform the following steps.

1. Click on ***"Error"*** button.

2. Is "**Should be divided**" included on highlighted ***errors***? (choose one)
    - o Yes
    - o No

3. Click on ***"Corrections"*** button.

4. How many words are ***corrected***? (choose one)
    - o 14
    - o 15
    - o 19
5. How many errors are ***corrected*** in the fourth paragraph? (choose one)
    - o 2
    - o 3
    - o Zero

6. Click on ***"Comments"*** button.

7. Move the cursor on the second highlighted, then press on play button.

8. Write down what you have heard.

   ....

   ....

9. Click on ***"Explain Ideas"*** button.

10. Move the cursor on each highlighted sentence. Then press on Avatar button on left side. The tutor mentioned that there is a paragraph unclear, which one. (choose one)
    - First paragraph.
    - Second paragraph.
    - Third paragraph.
    - Fourth paragraph.
11. How many sentences are highlighted? (choose one)
    - 4
    - 5
    - 9

❖ ***Task 6:***

To complete this task you need to perform the following steps.

1. Click on ***"Engage Thinking"*** button.

2. Move the cursor on the second highlighted, then press on play button. What did you hear? (choose one)
   - Expanding the conclusion.
   - Giving the reader simplest solutions.
   - Problems.
3. Click on ***"Suggestions Further"*** button.

4. Move the cursor on **last two highlighted sentences** and click on Avatar button. What is different between last two highlighted ***suggestions***? (choose one)

   - Start by talking about problem *and* read widely about topic
   - Extra study suggestions *and* come up with idea
   - Come up with idea *and* start at beginning of paragraph
   - Revisit class handouts *and* start at beginning of paragraph

5. Which sentence or paragraphs are highlighted completely and what is the ***suggestion*** for. (choose one from each column)
    - First paragraph.
    - Second paragraph.
    - Third paragraph.

    - Start by talking about problem.
    - Read widely about topic.
    - Revisit class handouts.

6. Click on ***"Mark"*** button.

7. Is the ***mark*** over 75? (choose one)
    - Yes
    - No
8. What is the ***mark*** of the third paragraph? (choose one)
    - 8/10
    - 7/10
    - 6/10
    - 10/10

Engagement questions:

1- How many ***errors*** have you seen?

....

2- Write down at least three ***errors***?

....

3- What is the ***correction*** of "**Also they**" and "**length**"?

....

4- How many ***comments*** have you seen?

....

5- In ***Explain Ideas*** part what is written about this statement "**Governments should find a solution for this problem.**"?

....

6- The tutor ***engaged student in thinking*** in this sentence "**To sum up...**" can you write the comment?

....

....

7- Write down one of the ***suggestions***?

....

....

8- What is the ***mark***?

....

Satisfaction questionnaire:

For each statement below, please express your view by placing a circle in the appropriate column.

5= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

No.	Statements	SA	A	U	D	SD
1	I think that I would like to use this system frequently	5	4	3	2	1
2	I found the system unnecessarily complex	5	4	3	2	1
3	I thought the system was easy to use	5	4	3	2	1
4	I think that I would need the support of a technical person to be able to use this system	5	4	3	2	1
5	I found the various functions in this system were well integrated	5	4	3	2	1
6	I thought there was too much inconsistency in this system	5	4	3	2	1
7	I would imagine that most people would learn to use this system very quickly	5	4	3	2	1
8	I found the system very cumbersome to use	5	4	3	2	1
9	I felt very confident using the system	5	4	3	2	1
10	I needed to learn a lot of things before I could get going with this system	5	4	3	2	1

If you have any comments or suggestions can you write please.

....
....
....
....
....

Thank you for your help.

A1.2: Control Group:

I am pleased to present myself to you as one of the postgraduate research students in the Faculty of Technology at the De Montfort University. I am currently investigating the use of multimodal metaphors in e-learning interfaces, and I would like to obtain your views regarding the use of such multimodal metaphors such as: text/graphic, recorded speech, and avatar with facial expressions.

Please complete the following procedure:

- ❖ Answer the pre-experiment questions.
- ❖ Read each task.
- ❖ Perform the tasks and answer the required related questions.
- ❖ Then answer recall questions.
- ❖ After that, answer the satisfaction questionnaire.

Please complete all the requirements as honestly as possible. It would be grateful if you could fill in the following questionnaire sincerely and express your views. Your privacy is guaranteed as you will not be mentioned in any part of the study. Thank you very much, and I highly appreciate your contribution.

Pre-experiment Questions:

- **General Information: (tick one please)**

1- Age:
- o 18-24.
- o 25-39.
- o 40-49.

2- Gender:
- o Male.
- o Female.

3- Education level:
- o Undergraduate.
- o Postgraduate.
- o Other. ....

- **Using Computer: (tick one please)**

1- How often do use the computer per week?
  - o 1-7 (hours)
  - o 8-14 (hours)
  - o More than 15(hours)
  - o Never.

2- Do you use any kind of E-learning system?
  - o Yes
  - o No

3- Do you contact your tutor through computer?
  - o Yes
  - o No

Tasks:

This software is used to see a feedback from your teacher. After logging in to the programme you will see your modules on top bar. To get your feedback, you need to press on a module, then choose tasks, then press on feedback. In front of you now the essay that you have submitted to your tutor. There are some samples that refer to its meaning which stated below .There are three tasks which you will go through to accomplish it. All tasks are classified on its level.

Errors = = , × and

Corrections = Y and

Comments =

Suggestions = + and +

Engage thinking = **!!**

Explain ideas = **??**

- ***Task 1:***

To complete this task you need to perform the following steps.

7. How many ***error*** have you seen. (choose one)
    - 20
    - 15
    - 18
    - 16

8. What is the ***correction*** of "**Children have**"?

    ....

9. Where is the positive ***comment*** (which paragraph)? (choose one)
    - 1st paragraph
    - 2nd paragraph
    - 3rd paragraph
    - 4th paragraph
    - 5th paragraph

- ***Task 2:***

To complete this task you need to perform the following steps.

1- What did tutor ask to ***explain idea*** on second paragraph? (choose one)
- Errors in sentences grammar.
- Discussed on the design.

2- What did the tutor mention to ***engage student thinking*** in last paragraph? (choose one)
- Expanding the conclusion.
- Giving the reader simplest solutions.
- Problems.

3- What is ***suggested*** for the fourth paragraph?

....

....

4- How much do you get (***Mark***)? (choose one)

- o 68
- o 74
- o 71
- o 69

❖ ***Task 3:***

To complete this task you need to perform the following steps.

8. How many ***errors*** in the third paragraph. (choose one)
    - o 5
    - o 3
    - o 1

9. Write down the ***correction*** of the following :

    "**board**" ....

    "**area**" ....

    "**healthy**" ....

10. To which the tutor ***comments*** on the second paragraph? (choose one)
    - o Errors in sentences, grammar.....
    - o Revisit class hand out.....

11. In which paragraph, did the tutor mention to " **You did not discuss the design, you focussed on the effects** " (choose one)
    - o First paragraph.
    - o Second paragraph.
    - o Third paragraph.
    - o Fourth paragraph.

❖ ***Task 4:***

To complete this task you need to perform the following steps.

1- On the fourth paragraph, the tutor ***engaged student thinking*** on " **This problem??** " (choose one)

- o True
- o False

2- Did the tutor ***suggest*** rewriting some sentences? (choose one)
   - Yes
   - No

3- How much do you get on the last paragraph? (choose one)
   - 8/10
   - 7/10
   - 6/10
   - 10/10

❖ ***Task 5:***

To complete this task you need to perform the following steps.

12. Is "**Should be divided**" included in ***errors***? (choose one)
    - Yes
    - No

13. How many words are ***corrected***? (choose one)
    - 14
    - 15
    - 11

14. How many errors are ***corrected*** in the fourth paragraph? (choose one)
    - 2
    - 3
    - Zero

15. Write down second ***comments*** please?

....

....

16. The tutor mentioned that there is a paragraph unclear, which one. (choose one)
    - First paragraph.
    - Second paragraph.
    - Third paragraph.
    - Fourth paragraph.

❖ ***Task 6:***

To complete this task you need to perform the following steps.

1- How many sentences or paragraph are considered to be ***explained ideas***? (choose one)
   - 4
   - 5
   - 9

2- What did tutor ***engage student thinking*** on third paragraph? (choose one)
   - Expanding the conclusion.
   - Giving the reader simplest solutions.
   - Problems.

3- What is different between last two ***suggestions***? (choose one)

   - Start by talking about problem ***and*** read widely about topic
   - Extra study suggestions ***and*** come up with idea
   - Come up with idea ***and*** start at beginning of paragraph
   - Revisit class handouts ***and*** start at beginning of paragraph

4- Match the correct answer with each other for ***suggestions*** .

o First paragraph.	o Revisit class handouts.
o Second paragraph.	o Read widely about topic.
o Third paragraph.	o Start by talking about problem.

5- Is the ***mark*** over 75? (choose one)
   - Yes
   - No

6- What is the ***mark*** of the third paragraph? (choose one)
   - 8/10
   - 7/10
   - 6/10
   - 10/10

Engagement questions:

1- How many ***errors*** have you seen?

....

2- Write down at least two words pointed as ***errors***?

....

3- What is the ***correction*** of "**Also they**" and "**length**"?

....

4- How many ***comments*** have you seen?

....

5- In ***Explain Ideas*** part what is written about this statement "**Governments should find a solution for this problem.**"?

....

6- The tutor ***engaged student in thinking*** in this sentence "**To sum up...**", can you write the comment?

....

7- Write down one of the ***suggestions***?

....

8- What is the ***mark***?

....

Satisfaction questionnaire:

For each statement below, please express your view by placing a circle in the appropriate column.

5= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

No.	Statements	SA	A	U	D	SD
1	I think that I would like to use this system frequently	5	4	3	2	1
2	I found the system unnecessarily complex	5	4	3	2	1
3	I thought the system was easy to use	5	4	3	2	1
4	I think that I would need the support of a technical person to be able to use this system	5	4	3	2	1
5	I found the various functions in this system were well integrated	5	4	3	2	1
6	I thought there was too much inconsistency in this system	5	4	3	2	1
7	I would imagine that most people would learn to use this system very quickly	5	4	3	2	1
8	I found the system very cumbersome to use	5	4	3	2	1
9	I felt very confident using the system	5	4	3	2	1
10	I needed to learn a lot of things before I could get going with this system	5	4	3	2	1

If you have any comments or suggestions can you write please.

....
....
....

Thank you for your help.

A2: User Profile Data:

		Experimental Group		Control Group	
Age	18-24	25%	5	35%	7
	25-39	65%	13	60%	12
	40-49	10%	2	5%	1
Gender	Male	55%	11	70%	14
	Female	45%	9	30%	6
Education level	Undergraduate	35%	7	40%	8
	Postgraduate	65%	13	60%	12
Using Computer Per Week	1-7 (hours)	25%	5	25%	5
	8-14 (hours)	35%	7	20%	4
	More than 15(hours)	40%	8	55%	11
Using E-learning System	Yes	90%	18	85%	17
	No	10%	2	15%	3
Contacting tutor by computer	Yes	85%	17	75%	15
	No	15%	3	25%	5

A3: Raw data of time spent to answer questions in Experimental group.

User ID	Task level						Task Type			Engagement Score
	Easy		Moderate		Complex					
	T1	T2	T3	T4	T5	T6	Type 1	Type 2	Type 3	
1	120	120	240	267.6	240	314.4	224.8	264.8	209.2	5
2	180	240	180	195	240	266.4	228.8	228.8	205	2
3	145.8	76.2	210.6	360	190.8	319.2	218.6	240.2	215.6	5
4	133.2	120	234.6	247.2	240	388.8	254	287.8	200.6	6
5	93	138	139.8	186	136.2	186	138.4	154	154.6	10
6	81	192	375	322.2	262.8	202.2	182	280	296.4	3
7	153	186.6	258.6	540	189.6	273	205.2	240.4	328.4	5
8	186.6	123.6	257.4	214.2	315	264.6	255.4	279	198.4	2
9	60	120	207	138.6	140.4	180	126.8	175.8	155.2	7
10	120	67.2	144.6	147	240	149.4	169.8	178	119.6	2
11	152.4	92.4	318	240	243	300	231.8	287	216.8	6
12	94.8	85.8	144	150.6	207	186.6	162.8	179.2	126.8	3
13	85.2	90	252.6	266.4	150	300	178.4	234.2	203	6
14	126	90	210.6	204	192.6	198	172.2	200.4	168.2	5
15	126.6	144.6	210	264.6	252.6	265.8	215	242.8	206.4	5
16	139.2	203.4	246.6	317.4	254.4	249.6	214.4	250.2	255.8	4
17	90	135	212.4	257.4	153.6	256.8	166.8	207.6	201.6	6
18	124.2	91.2	124.2	208.8	181.8	141	149	149	141.4	6
19	95.4	186.6	207.6	267	251.4	256.8	201.2	238.6	220.4	4
20	88.8	153	190.2	214.2	202.2	250.8	180.6	214.4	185.8	7

A4: Raw data of time spent to answer questions in Control group.

User ID	Task level						Task Type			Engagement Score
	Easy		Moderate		Complex					
	T1	T2	T3	T4	T5	T6	Type 1	Type 2	Type 3	
1	213	266.4	273.6	249.6	270	498	244.2	322.8	346	5
2	193.8	190.8	129	187.8	181.8	255	187.8	188.4	191.6	2
3	189.6	145.2	153	360	192	310.2	247.2	253.8	202.8	3
4	240	199.2	246	600	420	213.6	420	369.9	219.6	3
5	180	120	133.8	247.2	126	208.8	184.4	178.95	154.2	4
6	193.2	369	251.4	246.6	267	385.8	235.6	287.7	335.4	6
7	202.2	121.2	150.6	268.8	185.4	301.2	218.8	226.5	191	6
8	196.2	137.4	318	318	208.8	555.6	241	350.1	337	5
9	199.8	79.2	195	206.4	128.4	195	178.2	181.2	156.4	4
10	366.6	68.4	88.2	205.8	71.4	300	214.6	166.35	152.2	5
11	254.4	184.8	205.2	334.8	210.6	441.6	266.6	298.05	277.2	3
12	259.2	210	264	553.8	390.6	213.6	401.2	355.5	229.2	3
13	207.6	154.8	204	330	210.6	300	249.4	261.15	219.6	4
14	258.6	198.6	199.2	322.2	210	378	263.6	277.35	258.6	5
15	270	213.6	212.4	270	267	510	269	314.85	312	5
16	201.6	132.6	144	321.6	181.8	370.8	235	254.55	215.8	6
17	267	150.6	214.2	444	393.6	392.4	368.2	361.05	252.4	3
18	213.6	153	260.4	265.2	203.4	376.8	227.4	276.45	263.4	4
19	214.2	140.4	192.6	330	255.6	432	266.6	302.55	255	2
20	148.2	130.8	184.8	211.2	195.6	301.2	185	223.2	205.6	5

A5: Raw data of answering questions correctness in Experimental group.

User ID	Task level						Task Type			Engagement Score
	Easy		Moderate		Complex					
	T1	T2	T3	T4	T5	T6	Type 1	Type 2	Type 3	
1	3	3	2	6	6	6	100	87.50000005	84.61538462	5
2	3	3	4	5	4	6	86.66666667	87.50000005	92.30769231	2
3	3	2	2	6	6	6	100	87.50000005	76.92307692	5
4	3	3	4	6	4	6	86.66666667	87.50000005	100	6
5	3	2	4	5	5	6	93.33333333	93.75000006	84.61538462	10
6	2	3	3	5	5	6	86.66666667	87.50000005	84.61538462	3
7	3	2	4	5	6	6	100	100.0000001	84.61538462	5
8	3	2	3	6	6	6	100	93.75000006	84.61538462	2
9	3	3	4	4	5	6	93.33333333	93.75000006	84.61538462	7
10	2	2	4	4	4	4	66.66666667	75.00000005	76.92307692	2
11	2	2	3	6	6	6	93.33333333	93.75000006	84.61538462	6
12	3	3	2	4	6	6	100	87.50000005	69.23076923	3
13	3	3	4	6	5	6	93.33333333	93.75000006	100	6
14	3	2	3	5	6	5	93.33333333	87.50000005	76.92307692	5
15	2	3	2	6	6	4	80	75.00000005	84.61538462	5
16	3	3	4	6	4	4	73.33333333	75.00000005	100	4
17	3	3	4	6	5	6	93.33333333	93.75000006	100	6
18	3	3	4	6	6	6	100	100.0000001	100	6
19	2	2	4	6	6	5	86.66666667	93.75000006	92.30769231	4
20	3	3	3	6	5	6	93.33333333	87.50000005	92.30769231	7

A6: Raw data of answering questions correctness in Control group.

User ID	Task level						Task Type			Engagement Score
	Easy		Moderate		Complex					
	T1	T2	T3	T4	T5	T6	Type 1	Type 2	Type 3	
1	3	2	4	5	6	8	100	100	93.33333333	5
2	2	3	4	5	6	8	92.85714286	100	100	2
3	2	3	2	5	4	7	78.57142857	78.26086957	80	3
4	2	2	4	4	5	7	78.57142857	86.95652174	86.66666667	3
5	2	3	3	3	6	5	78.57142857	73.91304348	73.33333333	4
6	1	1	3	3	6	6	71.42857143	78.26086957	66.66666667	6
7	1	2	4	4	5	6	71.42857143	82.60869565	80	6
8	1	1	3	4	5	6	71.42857143	78.26086957	66.66666667	5
9	1	2	4	5	6	7	85.71428571	95.65217391	86.66666667	4
10	2	1	4	3	6	8	78.57142857	91.30434783	86.66666667	5
11	2	3	3	3	4	5	64.28571429	65.2173913	73.33333333	3
12	3	3	3	5	4	5	85.71428571	73.91304348	73.33333333	3
13	1	2	4	3	5	6	64.28571429	78.26086957	80	4
14	3	3	2	5	4	7	85.71428571	78.26086957	80	5
15	2	3	4	4	2	6	57.14285714	69.56521739	86.66666667	5
16	3	1	2	2	6	5	78.57142857	65.2173913	53.33333333	6
17	3	3	4	5	4	6	85.71428571	82.60869565	86.66666667	3
18	1	3	3	3	6	8	71.42857143	86.95652174	93.33333333	4
19	3	2	4	3	3	6	64.28571429	69.56521739	80	2
20	3	1	2	4	6	4	92.85714286	69.56521739	46.66666667	5

A7: Raw data of user's response to satisfaction questionnaire.

User ID	Experimental Group											Control Group										
	S1	S2	S3	S4	S5	S6	S7	S8	S9	10	Score	S1	S2	S3	S4	S5	S6	S7	S8	S9	10	Score
1	3	4	4	4	3	3	4	4	3	1	82.5	2	1	1	4	1	2	2	0	3	2	45
2	4	0	3	3	3	2	4	2	4	3	70	1	4	1	1	1	1	3	3	3	3	52.5
3	4	3	1	4	4	3	4	2	3	3	77.5	1	1	1	2	2	3	1	0	0	1	30
4	4	2	3	3	3	3	4	3	4	4	82.5	1	2	3	3	3	1	3	0	1	0	42.5
5	3	4	4	4	3	4	4	4	4	4	95	3	1	1	2	2	0	1	3	1	3	42.5
6	2	3	3	1	2	1	4	2	2	0	50	4	4	4	2	3	4	4	4	4	1	85
7	3	2	3	4	4	2	4	2	3	3	75	1	1	0	0	1	3	0	4	3	3	40
8	4	2	3	0	2	1	2	2	3	1	50	1	3	2	0	1	2	1	4	4	3	52.5
9	4	4	3	4	4	3	4	2	4	4	90	1	1	2	3	3	2	3	2	2	1	50
10	3	0	4	2	3	3	3	2	3	2	62.5	3	3	3	0	1	0	3	2	3	0	45
11	4	4	4	3	3	1	3	4	4	4	85	2	1	1	4	1	0	3	2	3	1	45
12	3	3	1	0	2	4	3	3	3	2	60	2	1	1	3	2	3	2	2	3	1	50
13	3	2	4	4	1	3	3	3	3	3	72.5	2	3	1	1	2	1	2	3	4	2	52.5
14	4	3	1	4	4	2	4	4	4	1	77.5	3	4	3	3	3	4	3	4	4	3	85
15	4	3	3	2	4	3	3	4	4	3	82.5	2	3	3	2	3	3	2	4	3	3	70
16	4	2	1	4	1	2	3	4	4	4	72.5	3	1	4	3	2	3	2	4	3	4	72.5
17	1	3	4	4	4	2	4	3	3	4	80	2	1	2	0	3	4	1	2	2	1	45
18	4	2	1	4	1	2	3	4	0	1	55	1	3	2	2	3	2	0	1	2	0	40
19	3	2	3	1	2	2	3	3	2	3	60	2	1	1	4	1	0	3	2	3	0	42.5
20	4	3	1	4	3	4	4	2	3	3	77.5	3	2	2	4	3	3	2	2	3	2	65

Appendix B- Experimental Stage 2: En effect of multimodal metaphors and feedback type in E-feedback interface on usability.

B1: Experimental work.

I am pleased to present myself to you as one of the postgraduate research students in the Faculty of Technology at the De Montfort University. I am currently investigating the use of multimodal metaphors in e-feedback interfaces, and I would like to obtain your views regarding the use of such multimodal metaphors such as: text/graphic, recorded speech, synthesis speech and avatar with facial expressions and body gestures.

Please complete the following procedure:

- ❖ Answer the pre-experiment questions.
- ❖ Watch demonstration of experiment.
- ❖ Perform the tasks.
- ❖ Then answer recall and recognitions questions.
- ❖ Rate each multimodal metaphors used.
- ❖ After that, answer the satisfaction questionnaire.
- ❖ Finally rate all interfaces.

Please complete all the requirements as honestly as possible. It would be grateful if you could fill in the following questionnaire sincerely and express your views. Your privacy is guaranteed as you will not be mentioned in any part of the study. Thank you very much, and I highly appreciate your contribution.

Pre-experiment Questions:

- **General Information: (tick one please)**

4- Age:
   - o 18-24.
   - o 25-39.
   - o 40-49.
   - o 50 +

5- Gender:
   - o Male.
   - o Female.

6- Education level:
   - o Undergraduate.
   - o Postgraduate.
   - o College.
   - o Other. ....

- **Using Computer: (tick one please)**

4- How often do use the computer per week?
  - o 1-7 (hours)
  - o 8-14 (hours)
  - o More than 15(hours)
  - o Never.

5- Do you use any kind of E-learning system?
  - o Yes
  - o No

3- Do you contact your tutor through computer?

  - o Yes
  - o No

- **About Feedback:**

1- Do you read your feedback that written by your tutor?
  - o Yes
  - o No

2- Do you find difficulties when you read your feedback?
  - o Yes
  - o No

3- Do you think that the addition of Face to Face (video) with facial expressions might help you in e-feedback?
  - o Yes
  - o No

4- Do you think that the addition of Synthesis speech might help you in e-feedback?
  - o Yes
  - o No

5- Do you think that the addition of Avatar with body gestures might help you in e-feedback?
  - o Yes
  - o No

Tasks:

First Interface

In this experiment you will see and listen to the feedback that present by instructor. This feedback will present in three different interfaces. It should be noted there are six different types of feedback content you see or listen. These feedback types are as following Error, Comments, Engage Thinking, Explain Ideas, Further Suggestions and Mark. In the first interface you need to press on Error button in the top of the interface then you will see the instructor talk on the left of the interface. At same time you will see the text about Error on the middle of the interface. After that you need to press on Comments button on the in the top of the interface then you will see the instructor talk on the left of the interface. At same time you will see the text about Comments on the middle of the interface. It is requested to concentrate on what is presented because you will be asked some questions about that. After that press on Questions button at the bottom of the interface, in this page you need to answer these questions either writes answer or choose correct answer. These questions about what are presented on the previous interface regarding feedback presented.

Part 1:

1- What kind of Error the tutor mentioned to?

…………………………………………………………………………………

2- The tutor talked about some errors in key figures and gave an example which is :(choose one)

a- Observed temperature discrepancyb- Decreased in temperature c-Temperature of fluid

3- The biggest weakness should include more details in one of main elements in coursework is :

………………………………………………………………………………..

4- The part that thought out well and identified strength and weakness of the approach is: (choose one)

a- Introductionb- main body c-literature review d-conclusion.

After completing answering questions press on Next button. In this question you ask to rate the way that presented feedback. So, rate each statement by tick on the appropriate to you.

Part 2:

Please rate each of the following facial expressions used by the Face to Face (video)? positively (+) or negatively (-)? (Choose one for each)

Neutral	+	-
Happy	+	-
Thinking	+	-
Unhappy	+	-

After completing, press on Next button. In this page you will see questionnaire about rate the interface. There are 18 statements, express your view by ticking in the appropriate column. **5**= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

Part 3:

For each statement below, please express your view by placing a circle in the appropriate column.

5= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

No.	Statements	SA	A	U	D	SD
1	I think that I would like to use this system frequently	5	4	3	2	1
2	I found the system unnecessarily complex	5	4	3	2	1
3	I thought the system was easy to use	5	4	3	2	1
4	I think that I would need the support of a technical person to be able to use this system	5	4	3	2	1
5	I found the various functions in this system were well integrated	5	4	3	2	1
6	I think there is too much inconsistency in this system	5	4	3	2	1
7	I would imagine that most people would learn to use this system very quickly	5	4	3	2	1
8	I found the system very cumbersome to use	5	4	3	2	1
9	I felt very confident using the system	5	4	3	2	1
10	I needed to learn a lot of things before I could get going with this system	5	4	3	2	1
11	I was excited and interested about the feedback	5	4	3	2	1
12	Classification of feedback type as buttons helped to improve my understanding of the presented information	5	4	3	2	1
13	I felt that I have a high level of control over my learning	5	4	3	2	1
14	The face to face‘s facial expressions increased my attention and I enjoyed it	5	4	3	2	1

15	I would receive feedback with face to face again	5	4	3	2	1
16	The face to face made it easier for me to follow and understand the feedback	5	4	3	2	1
17	Overall, I am satisfied with the interface	5	4	3	2	1
18	Overall, I had an enriching experience with the interface	5	4	3	2	1

Second Interface

After that, press on Next button. In the second interface you need to press on Engage Thinking button in the top of the interface then you will listen to the instructor talking about this type of feedback. At same time you will see the text about Engage Thinking on the middle of the interface. After that you need to press on Explain Ideas button on the in the top of the interface then you will see the instructor talking about this type of feedback. At same time you will see the text about Explain Ideas on the middle of the interface. It is requested to concentrate on what is presented because you will be asked some questions about that. After that press on Questions button at the bottom of the interface, in this page you need to answer these questions either writes answer or choose correct answer. These questions about what are presented on the previous interface regarding feedback presented.

Part 1:

1- To which part the tutor engaged student thinking in conclusion?

…………………………………………………………………………………

2- The tutor engaged student thinking to the new approach techniques limitations used: (Choose one)

a- Adding small glass   b- The need to glue the sensor

3- What is the idea that the tutor asked student to explain it more?

…………………………………………………………………………………..

4- What is the student requested to do in this part: (Choose one)

a-Investigate using new technique b- Bring advantages with the new approach   c- Bring disadvantages with the new approach

After completing answering questions press on Next button. In this question you ask to rate the way that presented feedback. So, rate each statement by tick on the appropriate to you.

Part 2:

Please rate each of the following voice expression used by the Synthesis Speech? Positively (+) or Negatively (-)? (Choose one for each)

Voice tone	+	-
Volume	+	-
Sequence of tone	+	-
Emphasis of tone	+	-

After completing, press on Next button. In this page you will see questionnaire about rate the interface. There are 18 statements, express your view by ticking in the appropriate column. **5**= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

Part 3:

For each statement below, please express your view by placing a circle in the appropriate column.

5= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

No.	Statements	SA	A	U	D	SD
1	I think that I would like to use this system frequently	5	4	3	2	1
2	I found the system unnecessarily complex	5	4	3	2	1
3	I thought the system was easy to use	5	4	3	2	1
4	I think that I would need the support of a technical person to be able to use this system	5	4	3	2	1
5	I found the various functions in this system were well integrated	5	4	3	2	1
6	I think there is too much inconsistency in this system	5	4	3	2	1
7	I would imagine that most people would learn to use this system very quickly	5	4	3	2	1
8	I found the system very cumbersome to use	5	4	3	2	1
9	I felt very confident using the system	5	4	3	2	1
10	I needed to learn a lot of things before I could get going with this system	5	4	3	2	1
11	I was excited and interested about the feedback	5	4	3	2	1
12	Classification of feedback type as buttons helped to improve my understanding of the presented information	5	4	3	2	1
13	I felt that I have a high level of control over my learning	5	4	3	2	1
14	The synthesis speech increased my attention and I	5	4	3	2	1

	enjoyed it					
15	I would receive feedback with synthesis speech again	5	4	3	2	1
16	The synthesis speech made it easier for me to follow and understand the feedback	5	4	3	2	1
17	Overall, I am satisfied with the interface	5	4	3	2	1
18	Overall, I had an enriching experience with the interface	5	4	3	2	1

Third Interface

After that, press on Next button .In the third interface you need to press on Further Suggestions button in the top of the interface then you will see the instructor talk on the left of the interface. At same time you will see the text about Further Suggestions on the middle of the interface. After that you need to press on Marks button on the in the top of the interface then you will see the instructor talk on the left of the interface. At same time you will see the text about Marks on the middle of the interface. It is requested to concentrate on what is presented because you will be asked some questions about that. After that press on Questions button at the bottom of the interface, in this page you need to answer these questions either writes answer or choose correct answer. These questions about what are presented on the previous interface regarding feedback presented.

Part 1:

1- What is suggested to student to record for each task?

……………………………………………………………...

2- The tutor is suggested to improve timeline of the work by: (Choose one)

a- Hard work. b- Look at previous project. c- Project plan (Gantt Chart).

3- What is the mark given for Literature review part?

…………………………………………………………….

4- Which mark is given to Presentation part? (Choose one)

a- 3/5 b- 7/10 c- 4/5 d- 30/50

After completing answering questions press on Next button. In this question you ask to rate the way that presented feedback. So, rate each statement by tick on the appropriate to you.

Part 2:

Please rate each of the following facial expressions used and body gestures by the Avatar with body gestures? positively (+) or negatively (-)? (Choose one for each)

Neutral	+	-
Happy	+	-
Thinking	+	-
Unhappy	+	-
Hands clenching-front	+	-
Arms folded	+	-
Chin Stroking	+	-
Pointing	+	-

After completing, press on Next button. In this page you will see questionnaire about rate the interface. There are 18 statements, express your view by ticking in the appropriate column. **5**= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

Part 3:

For each statement below, please express your view by placing a circle in the appropriate column.

5= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

No.	Statements	SA	A	U	D	SD
1	I think that I would like to use this system frequently	5	4	3	2	1
2	I found the system unnecessarily complex	5	4	3	2	1
3	I thought the system was easy to use	5	4	3	2	1
4	I think that I would need the support of a technical person to be able to use this system	5	4	3	2	1
5	I found the various functions in this system were well integrated	5	4	3	2	1
6	I think there is too much inconsistency in this system	5	4	3	2	1
7	I would imagine that most people would learn to use this system very quickly	5	4	3	2	1
8	I found the system very cumbersome to use	5	4	3	2	1
9	I felt very confident using the system	5	4	3	2	1
10	I needed to learn a lot of things before I could get going with this system	5	4	3	2	1
11	I was excited and interested about the feedback	5	4	3	2	1

12	Classification of feedback type as buttons helped to improve my understanding of the presented information	5	4	3	2	1
13	I felt that I have a high level of control over my learning	5	4	3	2	1
14	The Avatar's facial expressions with body gestures increased my attention and I enjoyed it	5	4	3	2	1
15	I would receive feedback with avatar with body gestures again	5	4	3	2	1
16	The avatar with body gestures made it easier for me to follow and understand the feedback	5	4	3	2	1
17	Overall, I am satisfied with the interface	5	4	3	2	1
18	Overall, I had an enriching experience with the interface	5	4	3	2	1

After that, press on Next button. In this page you will be asked to how useful you found each interface. Tick appropriate one to you. Also, if you have any suggestions or comments write down please. Thank you very much for your patience and generous help.

Rating all interfaces:

How useful did you find each of the following in the interface? (Circle as appropriate)

Face to Face interface . Least useful 1 2 3 4 5 Most useful

Synthesis Speech interface Least useful 1 2 3 4 5 Most useful

Avatar with Body Gestures Least useful 1 2 3 4 5 Most useful

Do you have any suggestions or comments?

____

____

____

____

Thank you very much for your patience and generous help.

B2: User Profile Data:

Age	18-24	38%	15
	25-39	59%	24
	40-49	3%	1
Gender	Male	74%	30
	Female	26%	10
Education level	Undergraduate	40%	16
	Postgraduate	60%	24
Using Computer Per Week	1-7 (hours)	15%	6
	8-14 (hours)	25%	10
	More than 15(hours)	60%	24
Using E-learning System	Yes	85%	34
	No	15%	6
Contacting tutor by computer	Yes	80%	32
	No	20%	8
Do you read your feedback	Yes	93%	37
	No	7%	3
Do you find difficulties when you read your feedback	Yes	88%	35
	No	12%	5
Do you think that the addition of Face to Face (video) with facial expressions might help you in e-feedback	Yes	70%	28
	No	30%	12
Do you think that the addition of Synthesis speech might help you in e-feedback	Yes	23%	9
	No	77%	31
Do you think that the addition of Avatar with body gestures might help you in e-feedback	Yes	97%	39
	No	3%	1

B3: Raw data of evaluation of Facial Expression in Face to Face platform.

Positive: 1. Negative: 0.

User ID	Facial Expressions			
	Neutral	Happy	Thinking	Unhappy
1	1	1	1	1
2	1	0	1	1
3	1	0	1	0
4	1	1	1	0
5	1	1	1	1
6	0	1	1	0
7	1	0	0	1
8	1	1	1	0
9	0	0	1	1
10	0	1	1	0
11	1	1	1	1
12	1	1	1	1
13	1	1	1	1
14	0	1	1	1
15	0	0	1	1
16	1	1	1	0
17	0	0	0	1
18	1	1	0	0
19	1	1	1	0
20	1	1	0	1
21	1	0	1	1
22	1	0	1	0
23	1	1	1	1
24	0	1	1	1
25	1	1	1	1
26	0	1	1	1
27	1	0	1	0
28	1	1	1	0
29	1	1	1	1
30	1	1	1	0
31	0	1	1	1
32	1	0	1	1
33	1	1	1	0
34	1	1	1	1
35	1	1	1	1
36	1	0	0	1

B4: Raw data of evaluation of Voice Expression in Synthesis Speech platform.

Positive: 1. Negative: 0.

User ID	Voice Expressions			
	Voice tone	Volume	Sequence of tone	Emphasis of tone
1	1	0	0	0
2	1	1	0	0
3	1	0	1	1
4	1	1	1	1
5	1	1	0	0
6	1	1	0	0
7	1	0	1	1
8	0	1	1	0
9	1	1	0	1
10	1	1	0	0
11	0	1	1	0
12	0	1	0	1
13	1	1	1	1
14	1	1	0	1
15	1	1	0	1
16	1	0	1	0
17	1	1	0	1
18	0	1	0	1
19	0	0	0	0
20	0	1	1	1
21	0	1	0	1
22	1	1	0	1
23	1	0	1	0
24	1	1	1	0
25	0	0	0	0
26	1	1	0	0
27	0	0	1	1
28	0	1	0	1
29	1	0	0	0
30	0	0	0	1
31	1	1	0	0
32	1	1	1	0
33	0	1	0	0
34	0	1	0	1
35	0	1	0	1
36	0	1	1	0

B5: Raw data of evaluation of Facial Expression and Body Gestures in Avatar Body Gestures platform.

Positive: 1. Negative: 0.

User ID	Facial Expressions and Body Gestures							
	Neutral	Happy	Thinking	Unhappy	Hands clenching-front	Arms folded	Chin Stroking	Pointing
1	1	1	0	1	0	1	1	0
2	1	0	1	1	1	1	1	1
3	1	1	0	1	1	1	1	1
4	1	1	1	0	1	1	1	1
5	1	1	1	0	1	1	0	1
6	0	0	0	1	1	1	0	1
7	1	1	1	0	1	0	0	0
8	1	1	1	1	0	1	1	0
9	1	0	1	0	1	1	1	1
10	1	1	1	0	1	1	1	1
11	1	1	1	0	0	0	0	1
12	1	1	1	1	1	1	1	1
13	1	1	0	0	0	0	1	0
14	1	1	1	1	1	1	0	1
15	1	1	0	0	1	1	1	1
16	1	1	1	1	1	1	1	1
17	1	1	1	0	1	1	1	1
18	1	1	1	0	1	0	1	1
19	1	0	1	0	1	1	1	0
20	1	0	0	1	0	1	0	0
21	1	1	1	1	1	0	0	1
22	1	0	1	1	0	1	0	1
23	1	0	0	1	0	0	1	1
24	0	0	1	0	1	1	1	1
25	1	1	1	0	1	1	0	1
26	1	1	0	0	1	1	1	0
27	1	1	1	0	1	1	0	1
28	1	0	1	0	1	1	1	1
29	1	1	0	1	0	1	1	0
30	1	1	1	1	1	0	0	1
31	1	1	1	0	1	0	0	1
32	1	1	1	0	1	0	1	1
33	1	1	1	0	1	1	0	0
34	0	1	1	0	0	1	1	1
35	1	1	1	0	0	1	1	1
36	1	0	1	1	1	0	1	1

B6: Raw data of time spent to watch feedback types in each platform.

Face To Face Platform (FTFP). Synthesis Speech Platform (SSP).

Avatar Body Gestures Platform (ABGP).

User ID	Feedback Types					
	Error	Comment	Engage Thinking	Explain Ideas	Further Suggestion	Mark
1	80	99	82	70	62	23
2	20	33	32	29	72	31
3	20	39	33	29	31	23
4	40	78	96	58	32	24
5	36	64	66	29	72	31
6	18	32	41	35	32	24
7	40	66	82	70	31	23
8	40	66	32	29	72	62
9	80	39	33	58	31	23
10	80	78	32	29	64	48
11	18	32	33	58	72	62
12	18	32	82	70	32	24
13	20	33	82	70	31	23
14	80	33	32	29	36	62
15	40	78	99	58	62	23
16	40	78	32	29	64	24
17	36	32	33	29	36	62
18	36	64	41	35	64	48
19	20	66	41	35	31	23
20	80	99	32	29	72	31
21	20	39	66	58	62	23
22	40	78	64	58	96	72
23	18	64	33	29	108	62
24	18	32	41	35	32	24
25	60	33	41	70	31	23
26	20	33	64	58	108	62
27	60	39	33	29	31	23
28	40	39	32	29	64	72
29	18	32	33	58	108	62
30	36	32	82	70	64	24
31	20	33	82	70	62	23
32	60	33	32	29	108	62
33	40	78	66	58	31	46
34	60	78	32	29	32	24
35	36	64	66	29	108	93
36	18	32	82	70	64	24

B7: Time spent to answer feedback questions for feedback types and feedback questions type.

User ID	Feedback Type												Feedback Questions Type								
	Error		Comment		Engage Thinking		Explain Ideas		Further Suggestion		Mark		All Questions			Recall			Recognition		
	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	FTFP	SSP	ABGP	FTFP	SSP	ABGP	FTFP	SSP	ABGP
1	46	63	34	33	105	79	127	34	25	22	42	72	176	345	161	109	184	47	67	161	114
2	76	43	64	21	157	102	92	93	18	32	19	55	204	444	124	119	259	50	85	185	74
3	53	90	23	62	142	148	68	100	29	45	21	11	228	458	106	143	290	74	85	168	32
4	71	22	44	41	111	183	79	241	41	19	11	31	178	614	102	93	294	60	85	320	42
5	85	49	47	20	89	105	30	99	25	36	22	21	201	323	104	134	194	61	67	129	43
6	66	101	78	73	99	147	92	166	31	22	41	26	318	504	120	167	246	53	151	258	67
7	61	55	45	99	166	136	137	180	21	37	19	39	260	619	116	116	302	58	144	317	58
8	67	37	21	44	133	176	155	94	23	22	47	26	169	558	118	104	309	45	65	249	73
9	63	83	55	75	189	242	33	174	26	72	20	34	276	638	152	146	431	98	130	207	54
10	83	21	32	67	204	87	232	104	12	29	34	20	203	627	95	104	291	41	99	336	54
11	64	22	87	77	189	72	43	132	24	35	27	27	250	436	113	86	261	59	164	175	54
12	31	39	33	42	29	82	73	162	10	28	19	21	145	346	78	70	111	38	75	235	40
13	19	66	62	38	139	150	114	112	13	82	59	58	185	515	212	85	289	95	100	226	117
14	46	63	110	24	115	180	164	234	83	76	21	56	243	693	236	109	295	159	134	398	77
15	55	38	33	78	221	165	159	175	43	66	32	28	204	720	169	93	386	109	111	334	60
16	38	58	48	49	102	182	152	111	36	45	21	63	193	547	165	96	284	81	97	263	84
17	37	88	73	58	167	200	178	172	28	82	16	48	256	717	174	125	367	110	131	350	64
18	21	48	51	30	253	163	189	155	13	60	23	49	150	760	145	69	416	73	81	344	72
19	37	75	96	87	78	345	173	132	21	90	90	78	295	728	279	112	423	111	183	305	168
20	10	70	87	43	133	256	268	178	13	75	51	91	210	835	230	80	389	88	130	446	142
21	42	58	49	60	102	105	295	245	45	64	28	53	209	747	190	100	207	109	109	540	81

22	94	95	44	49	184	89	156	157	16	32	85	28	282	586	161	189	273	48	93	313	113
23	82	31	29	69	112	247	248	78	35	64	44	93	211	685	236	113	359	99	98	326	137
24	99	46	68	68	160	175	93	230	16	67	66	85	281	658	234	145	335	83	136	323	151
25	10	21	46	65	110	61	129	78	66	46	70	33	142	378	215	31	171	112	111	207	103
26	33	73	47	76	162	184	172	106	11	93	40	94	229	624	238	106	346	104	123	278	134
27	57	39	83	87	209	135	115	175	32	37	54	45	266	634	168	96	344	69	170	290	99
28	54	48	100	86	256	129	273	135	45	35	55	26	288	793	161	102	385	80	186	408	81
29	45	106	76	99	100	113	59	144	39	26	68	25	326	416	158	151	213	65	175	203	93
30	22	75	45	95	321	267	259	125	26	43	78	21	237	972	168	97	588	69	140	384	99
31	43	83	130	92	121	250	107	184	10	30	20	62	348	662	122	126	371	40	222	291	82
32	18	89	66	55	178	107	181	145	10	25	25	27	228	611	87	107	285	35	121	326	52
33	37	92	44	78	234	111	167	85	35	28	62	45	251	597	170	129	345	63	122	252	107
34	65	75	21	34	89	105	170	49	33	35	63	26	195	413	157	140	194	68	55	219	89
35	49	84	67	36	300	145	278	132	85	23	90	41	236	855	239	133	445	108	103	410	131
36	56	48	47	66	170	245	145	160	32	45	48	45	217	720	170	104	415	77	113	305	93

B8: Raw data of answering questions correctness of each platform.

Face To Face Platform (FTFP). Synthesis Speech Platform (SSP). Avatar Body Gestures Platform (ABGP).

User ID	Feedback Type												Feedback Questions Type								
	Error		Comment		Engage Thinking		Explain Ideas		Further Suggestion		Mark		All Questions			Recall			Recognition		
	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	FTFP	SSP	ABGP	FTFP	SSP	ABGP	FTFP	SSP	ABGP
1	1	1	1	1	1	0	1	0	1	1	1	1	4	2	4	2	1	2	2	1	2
2	1	1	1	1	1	0	1	0	1	1	1	0	4	2	3	2	1	2	2	1	1
3	1	1	1	1	0	1	1	0	1	1	1	0	4	2	3	2	1	2	2	1	1
4	1	1	0	1	0	1	0	1	1	1	0	1	3	2	3	2	1	2	1	1	1
5	1	1	1	0	1	0	0	1	1	1	1	1	3	2	4	2	1	2	1	1	2
6	1	0	0	1	0	0	1	0	1	0	1	1	2	1	3	1	0	1	1	1	2
7	1	0	1	0	1	1	1	0	1	1	1	1	2	3	4	1	2	2	1	1	2
8	1	1	1	1	1	1	1	1	1	0	1	0	4	4	2	2	2	1	2	2	1
9	1	1	1	1	1	0	0	0	1	1	0	0	4	1	2	2	1	2	2	0	0
10	0	1	1	0	1	1	1	1	0	1	1	1	2	4	3	1	2	1	1	2	2
11	0	1	0	1	1	0	0	0	1	1	1	1	2	1	4	1	1	2	1	0	2
12	1	1	0	1	0	0	0	1	0	1	1	1	3	1	3	2	0	1	1	1	2
13	0	0	0	0	1	1	1	1	0	0	1	0	0	4	1	0	2	0	0	2	1
14	0	0	0	1	1	0	0	1	1	0	1	1	1	2	3	0	1	1	1	1	2
15	1	1	1	1	0	1	0	0	1	1	1	1	4	1	4	2	1	2	2	0	2
16	1	1	1	0	0	0	1	0	0	1	1	1	3	1	3	2	0	1	1	1	2
17	1	1	0	0	0	0	0	0	1	1	0	1	2	0	3	2	0	2	0	0	1
18	0	1	1	1	1	1	1	0	1	1	1	1	3	3	4	1	2	2	2	1	2
19	1	1	1	0	0	0	1	1	1	1	1	1	3	2	4	2	0	2	1	2	2
20	0	1	1	0	0	0	1	1	1	0	1	1	2	2	3	1	0	1	1	2	2
21	1	1	1	1	0	1	0	1	1	1	1	1	4	2	4	2	1	2	2	1	2
22	0	0	0	1	0	1	0	0	0	0	1	1	1	1	2	0	1	0	1	0	2
23	0	0	1	1	1	1	1	0	1	1	1	1	2	3	4	0	2	2	2	1	2
24	1	1	1	1	1	1	0	1	1	1	1	1	4	3	4	2	2	2	2	1	2
25	1	1	1	1	0	0	1	0	0	1	1	1	4	1	3	2	0	1	2	1	2
26	1	1	1	1	1	0	1	0	0	0	1	1	4	2	2	2	1	0	2	1	2

27	0	1	1	1	0	1	0	1	1	1	1	1	3	2	4	1	1	2	2	1	2
28	0	0	1	0	0	1	0	0	1	1	1	1	1	1	4	0	1	2	1	0	2
29	1	1	1	0	0	0	0	0	1	1	1	0	3	0	3	2	0	2	1	0	1
30	1	0	1	0	0	0	0	0	1	1	0	1	2	0	3	1	0	2	1	0	1
31	1	1	1	1	1	1	1	1	1	0	1	1	4	4	3	2	2	1	2	2	2
32	1	0	1	0	0	0	1	1	1	0	1	1	2	2	3	1	0	1	1	2	2
33	0	1	1	1	1	1	0	0	1	1	1	1	3	2	4	1	2	2	2	0	2
34	1	1	1	0	1	1	1	0	1	1	1	1	3	3	4	2	2	2	1	1	2
35	1	0	1	0	1	0	0	1	1	1	1	1	2	2	4	1	1	2	1	1	2
36	1	1	1	1	0	0	0	0	1	1	1	1	4	0	4	2	0	2	2	0	2

B8: Raw data of satisfaction questionnaire score of each satisfaction statement of Face to Face platform.

User	SUS 1										SUS 2							
ID	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
1	4	0	4	1	3	1	4	4	0	3	3	3	3	3	3	3	3	3
2	3	3	3	1	2	0	0	3	3	1	4	1	2	4	0	1	3	1
3	4	1	3	2	4	0	3	3	4	1	4	4	3	3	2	4	3	3
4	3	3	3	3	3	3	2	3	2	1	3	2	2	2	2	2	2	2
5	2	1	2	3	3	1	3	1	3	1	3	3	3	3	3	3	3	3
6	3	3	3	1	3	3	3	3	3	1	3	3	3	2	2	3	3	3
7	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3
8	4	3	4	4	3	3	3	3	3	3	3	3	3	4	4	4	4	4
9	4	3	4	3	3	3	3	3	4	0	4	2	3	4	3	4	3	4
10	3	2	3	4	3	3	3	3	3	4	3	4	2	3	3	3	3	3
11	4	3	4	4	4	3	4	2	4	3	4	4	4	4	3	3	4	2
12	3	2	3	3	3	3	2	3	2	3	2	2	2	2	2	2	3	3
13	4	3	4	0	4	2	0	0	0	0	3	3	3	3	3	3	3	3
14	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
15	3	3	3	1	2	0	0	3	3	1	4	1	2	4	0	1	3	1
16	3	3	3	3	3	3	2	3	2	1	3	2	2	2	2	2	2	2
17	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3
18	2	1	2	3	3	1	3	1	3	1	3	3	3	3	3	3	3	3
19	4	3	4	4	4	3	4	2	4	3	4	4	4	4	3	3	4	2
20	4	1	3	2	4	0	3	3	4	1	4	4	3	3	2	4	3	3
21	3	3	3	1	3	3	3	3	3	1	3	3	3	2	2	3	3	3
22	3	2	3	3	3	3	2	3	2	3	2	2	2	2	2	2	3	3
23	4	0	4	1	3	1	4	4	0	3	3	3	3	3	3	3	3	3
24	4	3	4	4	3	3	3	3	3	3	3	3	3	4	4	4	4	4
25	3	2	3	4	3	3	3	3	3	4	3	4	2	3	3	3	3	3
26	4	3	4	0	4	2	0	0	0	0	3	3	3	3	3	3	3	3
27	4	3	4	3	3	3	3	3	4	0	4	2	3	4	3	4	3	4
28	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
29	4	0	4	2	4	3	4	2	4	1	3	4	2	4	3	4	4	3
30	3	2	3	2	3	2	2	2	3	2	2	3	4	2	3	3	4	2

31	3	2	3	4	3	2	3	3	3	1	4	2	3	3	2	3	4	3
32	4	1	4	3	4	1	3	3	4	2	4	4	2	3	3	4	3	4
33	3	3	4	2	2	3	2	3	2	2	2	4	3	2	4	2	3	4
34	3	4	4	3	4	3	3	3	2	3	4	2	4	3	2	3	4	2
35	4	3	3	3	3	2	1	3	3	2	3	3	2	4	3	3	2	4
36	3	4	2	2	3	2	3	3	1	3	4	1	3	4	1	2	1	1

B9: Raw data of satisfaction questionnaire of each satisfaction statement of Synthesis Speech platform.

User	SUS 1										SUS 2							
ID	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
1	0	2	1	0	3	4	0	3	2	4	3	3	1	0	0	0	0	0
2	1	3	1	1	3	1	2	1	3	3	3	3	1	3	3	3	2	3
3	4	1	3	1	4	1	3	1	3	1	3	2	4	4	3	3	4	3
4	1	3	3	3	2	2	1	3	3	2	1	1	0	2	2	2	2	2
5	3	1	4	1	2	1	4	2	3	0	3	3	3	3	4	4	3	3
6	3	2	3	3	1	4	3	4	3	1	2	2	3	2	3	2	3	3
7	3	3	3	3	3	3	4	4	3	3	2	3	3	1	1	1	3	3
8	3	1	1	1	1	3	1	2	0	0	1	1	1	1	1	1	2	1
9	2	1	4	4	2	3	4	0	4	4	3	3	4	1	2	3	2	3
10	1	2	3	4	2	1	2	3	3	3	4	3	2	2	3	4	3	3
11	1	3	3	4	3	2	3	2	3	3	1	3	3	1	1	1	3	2
12	0	1	1	3	2	1	4	4	2	4	4	0	0	0	0	0	0	0
13	2	2	3	2	3	2	3	1	3	3	3	3	3	3	3	3	3	3
14	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
15	1	3	1	1	3	1	2	1	3	3	3	3	1	3	3	3	2	3
16	1	3	3	3	2	2	1	3	3	2	1	1	0	2	2	2	2	2
17	3	3	3	3	3	3	4	4	3	3	2	3	3	1	1	1	3	3
18	3	1	4	1	2	1	4	2	3	0	3	3	3	3	4	4	3	3
19	1	3	3	4	3	2	3	2	3	3	1	3	3	1	1	1	3	2
20	4	1	3	1	4	1	3	1	3	1	3	2	4	4	3	3	4	3
21	3	2	3	3	1	4	3	4	3	1	2	2	3	2	3	2	3	3
22	0	1	1	3	2	1	4	4	2	4	4	0	0	0	0	0	0	0
23	0	2	1	0	3	4	0	3	2	4	3	3	1	0	0	0	0	0
24	3	1	1	1	1	3	1	2	0	0	1	1	1	1	1	1	2	1
25	1	2	3	4	2	1	2	3	3	3	4	3	2	2	3	4	3	3
26	2	2	3	2	3	2	3	1	3	3	3	3	3	3	3	3	3	3
27	2	1	4	4	2	3	4	0	4	4	3	3	4	1	2	3	2	3
28	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
29	1	1	4	2	3	4	4	2	2	3	2	3	1	0	2	3	1	3
30	3	1	2	2	3	3	2	3	2	4	3	2	3	1	3	2	4	3

31	3	3	2	3	2	1	3	2	3	1	3	4	3	1	3	2	3	2
32	2	2	3	2	3	0	4	3	2	4	4	3	2	3	2	3	2	2
33	0	3	3	2	3	2	1	2	3	2	2	1	3	2	3	2	4	3
34	3	3	2	4	2	3	2	3	4	2	3	2	3	3	4	2	3	1
35	1	2	2	2	2	3	3	4	2	3	2	1	2	3	0	1	1	3
36	2	1	3	2	2	2	3	0	4	1	2	3	1	2	0	3	1	2

B10: Raw data of satisfaction questionnaire of each satisfaction statement of Avatar Body Gestures platform.

User	SUS 1										SUS 2							
ID	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	4	4	3	3	2	3	3	3	3	2	3	3	2	4	4	3	3	3
3	4	2	4	4	3	1	3	0	4	3	4	3	2	4	3	3	4	3
4	2	2	3	2	2	2	1	2	3	3	2	2	3	2	2	2	2	2
5	2	2	4	1	2	1	1	3	1	2	1	3	1	1	2	1	2	1
6	2	2	4	1	2	2	1	3	1	2	1	3	1	1	2	1	2	1
7	2	4	3	4	3	3	3	4	3	3	2	3	3	3	3	3	3	3
8	4	3	4	3	3	3	4	4	4	4	4	3	3	4	4	4	4	4
9	4	3	4	4	3	3	4	0	4	3	4	4	4	4	4	4	4	4
10	4	4	3	4	2	3	3	2	3	3	4	4	1	4	4	4	4	3
11	4	3	4	4	4	3	3	1	4	3	4	4	3	4	4	4	4	3
12	3	2	3	3	3	2	3	3	2	2	3	2	2	2	2	2	3	3
13	1	3	3	2	3	2	4	4	3	3	3	3	3	4	4	4	3	3
14	4	2	4	2	4	3	4	4	3	4	4	3	4	3	3	3	4	4
15	4	4	3	3	2	3	3	3	3	2	3	3	2	4	4	3	3	3
16	2	2	3	2	2	2	1	2	3	3	2	2	3	2	2	2	2	2
17	2	4	3	4	3	3	3	4	3	3	2	3	3	3	3	3	3	3
18	2	2	4	1	2	1	1	3	1	2	1	3	1	1	2	1	2	1
19	4	3	4	4	4	3	3	1	4	3	4	4	3	4	4	4	4	3
20	4	2	4	4	3	1	3	0	4	3	4	3	2	4	3	3	4	3
21	2	2	4	1	2	2	1	3	1	2	1	3	1	1	2	1	2	1
22	3	2	3	3	3	2	3	3	2	2	3	2	2	2	2	2	3	3
23	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	4	3	4	3	3	3	4	4	4	4	4	3	3	4	4	4	4	4
25	4	4	3	4	2	3	3	2	3	3	4	4	1	4	4	4	4	3
26	1	3	3	2	3	2	4	4	3	3	3	3	3	4	4	4	3	3
27	4	3	4	4	3	3	4	0	4	3	4	4	4	4	4	4	4	4
28	4	2	4	2	4	3	4	4	3	4	4	3	4	3	3	3	4	4
29	4	2	4	3	3	3	4	3	3	4	4	3	3	4	3	4	3	2
30	4	3	4	3	4	2	3	2	4	3	3	4	2	4	2	4	4	3

31	2	4	3	3	4	3	4	3	4	2	3	2	3	2	3	3	4	3
32	3	2	4	3	3	2	3	4	3	3	4	3	2	3	4	2	3	2
33	4	2	4	2	3	2	3	2	3	4	2	3	4	3	3	2	3	4
34	2	3	4	3	2	0	2	2	2	4	4	3	2	4	4	3	4	3
35	3	2	3	2	4	4	3	3	1	3	3	4	3	4	4	3	3	3
36	3	4	2	4	0	3	1	2	3	0	1	3	1	1	2	2	2	3

B11: Raw data of interfaces usefulness rate for each platform.

User ID	Usefulness of multimodal metaphors used		
	Face To Face Platform (FTFP)	Synthesis Speech Platform (SSP)	Avatar Body Gestures Platform (ABGP)
1	5	3	5
2	1	2	4
3	4	5	4
4	5	2	5
5	4	2	5
6	2	2	5
7	4	2	3
8	5	2	3
9	4	3	5
10	3	1	5
11	5	2	5
12	4	2	4
13	3	2	3
14	5	2	5
15	5	5	1
16	2	1	5
17	4	2	3
18	3	2	5
19	4	2	5
20	3	3	5
21	4	2	5
22	2	2	5
23	4	1	5
24	3	2	5
25	4	5	4
26	4	2	1
27	4	2	4
28	3	1	4
29	3	1	5
30	4	1	5
31	3	1	5
32	3	1	4
33	3	1	4
34	3	3	4
35	3	1	4
36	3	1	4

Appendix C- Experimental Stage 3: Investigate the effect of earcons and auditory icon and types of feedback on student's engagement in Avatar body gestures platform.

C1: Experiment work.

I am pleased to present myself to you as one of the postgraduate research students in the Faculty of Technology at the De Montfort University. I am currently investigating the use of multimodal metaphors in e-feedback interfaces, and I would like to obtain your views regarding the use of auditory non-speech metaphors in E-feedback interface.

Please complete the following procedure:

- ❖ Answer the pre-experiment questions.
- ❖ Watch demonstration of experiment.
- ❖ Perform the tasks.
- ❖ Then answer recall and recognitions questions.
- ❖ Evaluate each auditory non-speech metaphors used.
- ❖ After that, answer the satisfaction questionnaire.

Please complete all the requirements as honestly as possible. It would be grateful if you could fill in the following questionnaire sincerely and express your views. Your privacy is guaranteed as you will not be mentioned in any part of the study. Thank you very much, and I highly appreciate your contribution.

Pre-experiment Questions:

- **General Information: (tick one please)**

7- Age:
  - o 18-24.
  - o 25-39.
  - o 40-49.
  - o 50 +

8- Gender:
  - o Male.
  - o Female.

9- Education level:
  - o Undergraduate.
  - o Postgraduate.
  - o College.
  - o Other. ....

- **Using Computer: (tick one please)**

6- How often do use the computer per week?
   - 1-7 (hours)
   - 8-14 (hours)
   - More than 15(hours)
   - Never.

7- Do you use any kind of E-learning system?
   - Yes
   - No

   If yes, how often per week?

   - Less than 1 hour
   - 1-5 hours
   - 6-10 hours
   - More than 10 hours

8- Do you contact your tutor through computer?
   - Yes
   - No

9- Do you read your feedback that written by your tutor?
   - Yes
   - No

10- Do you find difficulties when you read your feedback?
   - Yes
   - No

Tasks:

Achievement level:

Part 1:

In this experiment you will see and listen to the feedback that present by instructor. It should be noted there are six different types of feedback content you see or listen. These feedback types are as following Error, Comments, Engage Thinking, Explain Ideas, Further Suggestions and Mark. First, you need to press on Error button in the top of the interface (at this moment you will hear auditory non-speech) then you will see the instructor talk on the left of the interface. At same time you will see the text about Error on the middle of the interface. After that you need to press on Comments button on the in the top of the interface (at this moment you will hear auditory non-speech) then you will see the instructor talk on the left of the interface. At same time you will see the text about Comments on the middle of the interface. It is requested to concentrate on what is presented because you will be asked some questions about that. After that press on Questions button at the bottom of the interface, in this page you need to answer these questions either writes answer or choose correct answer. These questions about what are presented on the previous interface regarding feedback presented.

1- What kind of Error the tutor mentioned to?

……………………………………………………………………………

2- The part that thought out well and identified strength and weakness of the approach is: (choose one)

a- Introductionb- main body c-literature review d-conclusion.

After completing answering questions press on Next button. In this question you ask to rate the way that presented feedback. So, rate each statement by tick on the appropriate to you.

Part 2:

After that, press on Next button. Secondly, you need to press on Engage Thinking button in the top of the interface (at this moment you will hear auditory non-speech) then you will listen to the instructor talking about this type of feedback. At same time you will see the text about Engage Thinking on the middle of the interface. After that you need to press on Explain Ideas button on the in the top of the interface (at this moment you will hear auditory non-speech) then you will see the instructor talking about this type of feedback. At same time you will see the text about Explain Ideas on the middle of the interface. It is requested to concentrate on what is presented because you will be asked some questions about that. After that press on Questions button at the bottom of the interface, in this page you need to answer these questions either writes answer or choose correct answer. These questions about what are presented on the previous interface regarding feedback presented.

1- To which part the tutor engaged student thinking in conclusion?

……………………………………………………………………………

2- What is the student requested to do in this part: (Choose one)

a- Investigate using new technique b- Bring advantages with the new approach

c- Bring disadvantages with the new approach

After completing answering questions press on Next button. In this question you ask to rate the way that presented feedback. So, rate each statement by tick on the appropriate to you.

Part 3:

After that, press on Next button .Thirdly, you need to press on Further Suggestions button in the top of the interface (at this moment you will hear auditory non-speech) then you will see the instructor talk on the left of the interface. At same time you will see the text about Further Suggestions on the middle of the interface. After that you need to press on Marks button on the in the top of the interface (at this moment you will hear auditory non-speech) then you will see the instructor talk on the left of the interface. At same time you will see the text about Marks on the middle of the interface. It is requested to concentrate on what is presented because you will be asked some questions about that. After that press on Questions button at the bottom of the interface, in this page you need to answer these questions either writes answer or choose correct answer. These questions about what are presented on the previous interface regarding feedback presented.

1- What is suggested to student to record for each task?

……………………………………………………………...

2- Which mark is given to Presentation part? (Choose one)

b- 3/5 b- 7/10 c- 4/5 d- 30/50

Engagement Test:

Part 1:

The following six feedback types is going to be delivered, point out where sound used to indicate each of the following:

- Error.
- Comment.
- Engage Thinking.
- Explain Ideas.
- Further Suggestion.
- Mark.
- Feedback high Important.
- Feedback Medium Important.
- Feedback Low Important.

Part 2:

In this test you will hear two sounds for each of feedback types and feedback important level. Choose the correct sound (write number 1,2,3…. In box).

Feedback types/level	Non-speech sounds
Error	
Comment	
Engage Thinking	
Explain Ideas	
Further Suggestion	
Mark	
Feedback high Important	
Feedback Medium Important	
Feedback Low Important	

Evaluation of Non-speech sounds:

How did you find the use of the added Non-speech sounds in the tested e-feedback interface? (Tick in appropriate place)

Agree	Feeling	Disagree
	Irritation	
	Disappointment	
	Usefulness	
	Concentration	

Satisfaction:

For each statement below, please express your view by placing a circle in the appropriate column.

5= **(SA)** Strongly Agree. **4**= **(A)** Agree. **3**= **(U)** Undecided. **2**= **(D)** Disagree. **1**= **(SD)** Strongly Disagree.

No	Statements	SA	A	U	D	SD
1	I think that I would like to use this system frequently	5	4	3	2	1
2	I found the system unnecessarily complex	5	4	3	2	1
3	I thought the system was easy to use	5	4	3	2	1
4	I think that I would need the support of a technical person to be able to use this system	5	4	3	2	1
5	I found the various functions in this system were well integrated	5	4	3	2	1
6	I think there is too much inconsistency in this system	5	4	3	2	1

7	I would imagine that most people would learn to use this system very quickly	5	4	3	2	1
8	I found the system very cumbersome to use	5	4	3	2	1
9	I felt very confident using the system	5	4	3	2	1
10	I needed to learn a lot of things before I could get going with this system	5	4	3	2	1

Do you have any suggestions or comments?

____
____
____
____

Thank you very much for your patience and generous help.

C2: User Profile Data:

Age	18-24	38%	9
	25-39	56%	14
	40-49	6%	1
Gender	Male	64%	15
	Female	36%	9
Education level	Undergraduate	65%	16
	Postgraduate	35%	8
Using Computer Per Week	1-7 (hours)	15%	4
	8-14 (hours)	25%	6
	More than 15(hours)	60%	14
Using E-learning System	Yes	90%	22
	No	10%	2
Contacting tutor by computer	Yes	80%	19
	No	20%	5
Do you read your feedback	Yes	95%	23
	No	5%	1
Do you find difficulties when you read your feedback	Yes	80%	19
	No	20%	5

C3: Raw data of correctness answer for achievement level of feedback types and feedback questions type.

User ID	Feedback Type						Feedback Questions Type						
	Error	Comment	Engage Thinking	Explain Ideas	Further Suggestion	Mark	Recall			Recognition			Score
							Q1	Q2	Q3	Q1	Q2	Q3	
1	1	1	0	1	1	0	1	0	1	1	1	0	4
2	1	0	1	1	1	1	1	1	1	0	1	1	5
3	1	0	1	0	1	1	1	1	1	0	0	1	4
4	1	0	1	1	1	0	1	1	1	0	1	0	4
5	0	1	1	1	0	1	0	1	0	1	1	1	4
6	1	1	1	1	0	1	1	1	0	1	1	1	5
7	1	0	1	1	1	1	1	1	1	0	1	1	5
8	1	1	1	0	1	1	1	1	1	1	0	1	5
9	1	0	1	1	1	0	1	1	1	0	1	0	4
10	1	1	1	0	1	0	1	1	1	1	0	0	4
11	1	1	1	1	1	1	1	1	1	1	1	1	6
12	0	1	1	0	0	1	0	1	0	1	0	1	3
13	1	0	1	1	1	1	1	1	1	0	1	1	5
14	1	1	1	0	1	1	1	1	1	1	0	1	5
15	1	1	1	1	0	0	1	1	0	1	1	0	4
16	0	0	1	1	1	1	0	1	1	0	1	1	4
17	1	1	1	1	1	1	1	1	1	1	1	1	6
18	1	0	1	0	1	1	1	1	1	0	0	1	4
19	1	1	1	1	0	0	1	1	0	1	1	0	4
20	1	1	0	0	1	1	1	0	1	1	0	1	4
21	1	0	1	1	1	0	1	1	1	0	1	0	4
22	1	0	1	1	1	1	1	1	1	0	1	1	5
23	1	1	1	1	0	1	1	1	0	1	1	1	5
24	1	0	1	1	1	0	1	1	1	0	1	0	4

C4: Raw data of correctness answers for engagement test 1.

User ID	Feedback Types						Feedback Important Level		
	Error	Comment	Engage Thinking	Explain Ideas	Further Suggestion	Mark	Feedback High Important	Feedback medium important	Feedback low important
1	1	1	0	1	1	1	1	1	1
2	1	0	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	0	1
4	0	1	1	0	1	0	1	1	1
5	1	0	1	1	1	1	1	1	1
6	1	1	0	1	1	0	1	1	0
7	1	1	1	0	1	1	1	1	1
8	1	1	1	1	1	1	1	0	1
9	1	1	1	0	1	1	1	0	0
10	1	0	1	0	1	1	1	1	1
11	1	0	0	1	0	0	0	1	0
12	1	1	0	1	1	1	1	0	0
13	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	0	1	1	1	1	0
16	1	1	1	1	1	1	1	0	1
17	1	1	1	1	1	0	1	1	1
18	1	1	1	0	1	1	1	1	0
19	1	1	1	1	1	1	1	0	0
20	1	0	1	1	1	1	0	1	1
21	1	1	1	0	0	1	1	1	1
22	1	0	0	1	1	1	1	0	1
23	1	1	1	1	1	1	1	1	0
24	1	0	0	0	1	1	0	1	1

C5: Raw data of correctness answers for engagement test 2.

User ID	Feedback Types						Feedback Important Level		
	Error	Comment	Engage Thinking	Explain Ideas	Further Suggestion	Mark	Feedback High Important	Feedback medium important	Feedback low important
1	1	1	1	1	1	1	1	1	1
2	1	1	1	0	1	1	1	0	1
3	1	1	0	1	1	0	1	1	1
4	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1
6	1	1	1	0	1	0	1	1	1
7	1	0	0	1	1	0	1	1	1
8	1	1	1	0	0	1	0	1	0
9	1	1	1	1	1	1	1	1	1
10	1	0	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	0
12	1	1	1	1	1	1	1	1	1
13	1	0	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	0	1	0	1	1	1
16	1	1	1	1	1	1	1	0	0
17	1	1	1	0	1	1	1	1	1
18	1	0	1	1	1	0	1	1	1
19	1	1	0	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1
21	1	0	0	0	1	1	1	1	1
22	1	1	1	1	1	0	1	1	1
23	1	1	0	1	1	1	1	1	1
24	1	1	1	0	1	1	1	1	1

C6: Raw data of user's evaluation of Non-Speech sounds used.

Agree: 1. Disagree: 0.

User ID	Usefulness	Concentration	Irritation	Disappointment
1	1	1	1	1
2	1	1	0	0
3	1	1	1	1
4	0	1	0	1
5	1	1	1	0
6	1	1	1	1
7	1	0	1	0
8	1	1	0	0
9	1	0	1	0
10	1	1	1	1
11	0	1	1	1
12	1	1	1	1
13	1	1	1	0
14	1	0	1	1
15	1	1	0	1
16	1	0	1	0
17	1	1	1	1
18	1	1	0	0
19	0	1	1	0
20	1	1	0	1
21	1	1	1	1
22	0	1	0	0
23	1	0	0	1
24	1	1	1	0

C7: Raw data of satisfaction questionnaire for each satisfaction statement.

User ID	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**Score**
1	4	4	3	4	4	4	3	3	4	4	92.5
2	4	3	4	2	3	2	3	2	3	4	75
3	3	4	4	3	4	4	3	4	4	4	92.5
4	2	4	4	3	4	4	4	3	4	4	90
5	4	2	3	4	3	3	3	2	4	4	80
6	4	2	3	1	4	4	3	4	3	4	80
7	3	3	4	2	2	4	4	4	4	4	85
8	3	4	4	3	4	2	4	3	3	4	85
9	4	4	4	3	4	1	3	2	3	3	77.5
10	4	3	3	2	2	1	2	4	4	4	72.5
11	1	4	3	4	3	3	4	4	4	2	80
12	2	4	4	3	2	4	4	3	3	3	80
13	3	3	4	2	4	3	3	4	4	4	85
14	3	2	4	0	4	3	2	4	4	3	72.5
15	3	4	4	3	3	4	4	3	3	3	85
16	3	4	4	2	4	2	4	4	4	4	87.5
17	4	2	3	3	3	4	3	3	3	4	80
18	4	4	4	4	4	3	4	4	4	4	97.5
19	4	1	4	3	4	4	4	3	4	3	85
20	2	0	3	3	3	2	3	3	3	4	65
21	3	4	4	2	4	1	3	2	4	3	75
22	4	2	4	4	3	0	4	4	4	2	77.5
23	3	4	4	2	3	3	4	4	4	2	82.5
24	4	4	4	3	4	4	4	4	4	3	95